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Report on

Test of Communications, Inc., 50-watt

Radio Telephone Equipment

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SECTION I

AUTHORIZATION

1-1. The tests herein reported were authorized by Bureau of Ships letter S67/43 (11-19-DR6) of 23 November, 1940. The above letter assigned Bureau of Ships Problem T5-39C, Priority "A," to cover the tests of the Communications, Inc., 50-watt radio telephone equipment.

OBJECT OF TEST

1-2. The object of the tests was:

(a) To examine the equipment for the purpose of determining its ability to withstand the rigors of Naval usage.

(b) To determine the performance of the equipment when it was subjected to the various conditions likely to be encountered in the Naval Service.

(c) To ascertain what changes or modifications are necessary or desirable in the equipment to insure satisfactory operation under Naval Service conditions.

ABSTRACT OF TESTS

1-3. The tests herein reported were conducted with a view of determining the potentialities of the equipment under Naval conditions of operation. Briefly, inspection and tests were conducted as follows:

(a) Transmitter

General examination of equipment

(1) Check of vacuum tubes employed and method of mounting.
(2) Inspection of panel controls.
(3) Investigation of tuning methods.
(4) Accessibility and protection of personnel.
(5) Wiring.
(6) Insulation.
(7) Weights and dimensions.
(8) General physical construction, ventilation.
(9) Transmitter components. Switches, resistors, fuses, and capacitors.
(10) Mounting and shock proofing methods.
(11) Microphone.
(12) Connection facilities.

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(13) Power equipment.
(14) Antenna.

Operational data and tests

(1) Power output and operation into an actual antenna.
(2) Inclination test.
(3) Vibration test.
(4) Effect of temperature variations.
(5) Effect of humidity variations.
(6) Locked key operation.
(7) Percentage modulation and harmonic distortion.
(8) Audio frequency fidelity.
(9) Break-in methods.
(10) Transmitter control.
(11) Power required from supply line.
(12) Effect of short-circuiting or open-circuiting the antenna.
(13) Vacuum tube operating conditions.
(14) Instruction book.
(15) Spare parts.

(b) Receiver

General examination of equipment

(1) Electrical inspection of circuits, etc.
(2) Mechanical inspection of components, controls, etc.
(3) Instruction Book.
(4) Spare parts.

Operational data and tests

(1) Listening tests on antenna.
(2) Laboratory measurements in shielded room.
   A. Sensitivity and noise output.
   B. Image ratio.
   C. I. F. response.
   D. Selectivity.
   E. Resonant overload.
   F. Effect of modulation depth.
   G. Gain control range.
   H. Radiation of oscillator frequency.
(3) Effects of temperature variations.
(4) Effects of humidity variations.
(5) Effects of vibration.

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Conclusions

(a) The general appearance and construction of the Communications Company equipment is satisfactory. Components of good quality are employed, although not all parts would comply with the requirements of Naval specifications. Standard tubes of a minimum number of types are used. (Transmitter, Receiver)

(b) The system of tuning employed in the transmitter makes the adjustment of the equipment rather difficult if optimum results on all bands is desired. (Transmitter)

(c) The power output of the transmitter is considerably less than the nominal 50-watts unless the side band power is included in the power output figure. (Transmitter)

(d) The transmitting equipment is incapable of continuous operation due to overloads which exist in the dynamotor and PA stage. Plug-in coils are used which were found to overheat after a few minutes of operation. (Transmitter)

(e) The shock mounting provided does not protect the equipment from damage when subjected to vibration. (Transmitter, Receiver)

(f) A number of minor modifications are indicated to improve operation and maintenance of the transmitter, receiver, and power circuits. (Transmitter, Receiver)

(g) The receiver has moderate selectivity, low sensitivity, poor image ratio, and satisfactory I.F. response as compared to similar equipment under test. Its sensitivity on INTERSHIP position is about 7 DB lower than on the other positions. (Receiver)

(h) The AVC characteristics are apparently satisfactory for the type of service for which the receiver was designed. (Receiver)

(i) The receiver frequency is greatly affected on "TUNE" SHIP-SHORE operation both by humidity and temperature. (Receiver)

(j) Receiver sensitivity is adversely affected by low temperatures. (Receiver)

(k) High humidity seems to affect the sensitivity adversely when started cold, recovery being slow on the SHIP-SHORE position. Exposure to high humidity while in operation does not seem to affect the sensitivity. (Receiver)

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(l) The receiver is not designed to withstand vibration.

(m) Modulation measurements indicate linear response up to about 50% modulation. (Receiver)

(n) Many changes would be necessary in the receiver to closely approach Naval requirements. (Receiver)

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Recommendations

It is recommended:

(a) That the use of types 6C5 and 6V6 vacuum tubes be approved, since they are both commercially available. (See par. 2-1-b) (Transmitter)

(b) That the type 807 modulator tubes be relocated to prevent their striking the modulation transformer. (See par. 2-1-d) (Transmitter)

(c) That filament circuits of the transmitter indicator lamp and vacuum tubes be kept separate. (See par. 2-1-f) (Transmitter)

(d) That the frequency switch control knob be equipped with two set screws or, preferably, pinned to the shaft. (See par. 2-2-b) (Transmitter, Receiver)

(e) That crystal holders or sockets be altered to eliminate the possibility of inserting holders incorrectly. (See par. 2-3-a) (3-2-t) (Transmitter, Receiver)

(f) That necessary changes be made in the construction of the three-section frequency-change switch to enable the unit to be removed and replaced without extensive disassembly. (See par. 2-4) (Transmitter)

(g) That adequate warning plates be provided on units containing high voltage to reduce hazards to personnel. (See par. 2-4) (Transmitter, Receiver)

(h) That additional precautions be taken to adequately secure and protect the wiring, and that improved soldering practises be required. (See par. 2-5-b) (Par. 3-2-(j), (u), (v), (cc) (Transmitter, Receiver)

(i) That, while phenolic insulation is employed in the transmitter in locations normally prohibited by Navy standard practise, the use of this material be considered acceptable in the equipment in question. (See par. 2-6) (Transmitter)

(j) That the use of steel be kept to a minimum and that the use of unprotected steel be eliminated. (See par. 2-8-b) (par. 3-2-l) (Transmitter, Receiver)

(k) That consideration be given to replacing steel parts of Lord mounts with some unplated, corrosion resisting metal, such as monel. (See par. 2-8-b) (Transmitter, Receiver)

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(l) That consideration be given to supplying ventilating means in the transmitting equipment to reduce overheating effects noted. (See par. 2-8-c) (Transmitter)

(m) That consideration be given to waiving the requirement of drip-proof construction. (See par. 2-8-d) (Transmitter, Receiver)

(n) That necessary changes be made to permit access to both commutators and bearings of the dynamotor without removal of the machine from the power unit chassis. (See par. 2-8-e) (Transmitter)

(o) That all meters necessary for the proper adjustment of the transmitter be supplied. (See par. 2-9-a) (Transmitter)

(p) That meter jacks be plainly marked with their function and the range of the meter required. (See par. 2-9-a) (Transmitter)

(q) That an asbestos sleeve be employed around the body of wire wound resistors where these resistors are mounted in fuse clips to prevent damage to the insulating coating. (See par. 2-9-c) (Transmitter)

(r) That each fuse position be marked with the rating of the fuse required. (See par. 2-9-d) (Transmitter, Receiver)

(s) That the method of securing the shock mounts of the modulator-power unit be modified to permit replacement. (See par. 2-10-a) (Transmitter, Receiver)

(t) That shock mounting be improved and that tubes and coils be properly secured to prevent dislodgment. (See par. 2-10-a, 2-17, 2-1-d) (Par. 3-8) (Transmitter, Receiver)

(u) That a suitable mounting be provided for the microphone, proof against roll and vibration. (See par. 2-10-b) (Transmitter)

(v) That stronger screw threads be provided in the cast microphone case. (See par. 2-11) (Transmitter)

(w) That cable connectors be carefully inspected for accuracy of threading. (See par. 2-12) (Transmitter, Receiver)

(x) That larger ground studs, secured against turning, be provided on the transmitter and receiver. (See par. 2-12) (Transmitter, Receiver)

(y) That the necessary steps be taken to insure that the transmitter dynamotor will not be subjected to loads in excess of its normal rating. (See par. 2-13) (Transmitter)

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(z) That if use of fish pole antenna in Naval service is contemplated that further tests be conducted under service conditions to determine adequacy of installation. (See par. 2-14) (Transmitter, Receiver)

(aa) That consideration be given to re-rating the output power of the transmitter to conform to usual Navy practise. (See par. 2-15) (Transmitter)

(ab) That adjustment of the PA and antenna circuits be made less critical so that a satisfactory compromise setting may be attained more easily. (See par. 2-15) (Transmitter)

(ac) That overheating of PA coils be eliminated. (See par. 2-20) (Transmitter)

(ad) That necessary changes be made to insure symmetrical modulation and that the overmodulation present under certain conditions be eliminated. (See par. 2-21) (Transmitter)

(ae) That consideration be given to protecting PA tubes from excessive overloads resulting from shorting or opening the antenna. (See par. 2-26) (Transmitter)

(af) That necessary design changes be made to prevent operation of the type 807 PA tubes in excess of their normal rating. (See par. 2-27) (Transmitter)

(ag) That a suitable, complete instruction book be furnished. (See par. 2-28) (Transmitter, Receiver)

(ak) That consideration be given to providing sufficient and suitable spare parts with the equipment. (See par. 2-29) (Transmitter, Receiver)

(ai) That consideration be given to the type of tuning which requires adjustment by ear, complicating tuning in the presence of strong, local acoustical noise. (See par. 3-1-(1)) (Receiver)

(aj) That the use of mounting strips in the receiver be employed instead of the cylinders now used, to facilitate servicing. (See pars. 3-2 (aa), (j), (x), (z)) (Receiver)

(ak) That the metal can condenser in the receiver under the tuning condenser be made more accessible for replacement. (See par. 3-2-j-x) (Receiver)

(al) That the sockets in use in the receiver be replaced by Navy approved types, with ceramic insulation for the r.f. circuits. (3-2-q-t) (Receiver)

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(am) That more permanent means of socket designation be employed. (3-2-q-t) (Receiver)

(an) That the power supply choke be metal encased. (See par. 3-2-s) (Receiver)

(ao) That the speaker output transformer be protected against moisture. (See par. 3-2-s) (Receiver)

(ap) That Navy approved condensers be used instead of the electrolytic condensers now in the receiver. (See par. 3-2-x) (Receiver)

(aq) That ceramic insulation be used in receiver r.f. circuits. (See par. 3-2-y) (Receiver)

(ar) That self-tapping screws be replaced by more reliable means of fastening. (See par. 3-2-dd) (Receiver)

(as) That steps be taken to reduce the radiation voltages appearing at the antenna terminal. (See par. 3-6-f) (Receiver)

(at) That the cause of low temperatures affecting the sensitivity of the receiver be determined and corrected. (See par. 3-9-r) (Receiver)

(au) That the cause of temperature and humidity affecting the receiver frequency on SHIP-SHORE "TUNE" position be determined and corrected. (See par. 3-9-s) (Receiver)

(av) That the receiver be made capable of withstanding vibration. (See par. 3-8) (Receiver)

(aw) That consideration be given to approving the tube types used in the receiver. (See par. 3-1-f) (Receiver)

(ax) That the crystal clamp be relocated so that it does not interfere with the removal of the receiver chassis from the cabinet. (See par. 3-2-t) (Receiver)

(ay) That precautions be taken to insure that receiver adjustments present no difficulties. (See par. 3-2-v) (Receiver)

(az) That steps be taken to insure that the oscillator of the INTERSHIP section cannot be received on the SHIP-SHORE section operating with continuously variable tuning. (Receiver)

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MATERIAL UNDER TEST

1-4. The material under test consisted of the following:

1 - Model 50A transmitter unit
Communications Co., Inc.
Serial No. 188

1 - Model 66B receiver unit
Communications Co., Inc.
Serial No. 197

1 - Model 56B modulator and power unit
Communications Co., Inc.
Serial No. 197

1 - Universal Handi-Mike
Model 200TC
Type: Carbon

1 - Fish-pole antenna
Model 2738
Serial No. 110

1 - Loud speaker

The following cables:

1 - 12-1/2 ft. modulator-to-transmitter cable.
1 - 10-1/2 ft. modulator-to-receiver cable.
1 - 5 ft. modulator-to-battery cable.

The following parts packed together:

3 - extra load coils (plug in type)
1 - jumper coil (plug in type)
1 - Littelfuse 1/2 a, 1000 v
1 - Buss 50 amp. fuse
2 - Buss 10 amp. fuses

1 - Envelope containing:
Instruction pamphlet for Model 80 equipment.
Instruction pamphlet for Model 60 equipment.
Loose instruction sheets for the 50-watt marine equipment shipped.

The following tubes and crystals were shipped in-place in the transmitter unit:

2 - Type 807 vacuum tubes.
1 - Type 6V6 vacuum tube.

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1 - Valpey type CM1 crystal, 2118 Kc.; Serial No. OH350
1 - Bliley type MC5 crystal, 2142 Kc. ± .04%
1 - Valpey type CM1 crystal, 2738 Kc.; Serial No. OH352
1 - Valpey type CM1 crystal, 2670 Kc.; Serial No. OG338.

The following tubes and crystals were shipped in-place in the receiver unit:

4 - Type 6S7 vacuum tubes.
2 - Type 6K8 vacuum tubes.
1 - Type 6SQ7 vacuum tube.
1 - Type 6SF5 vacuum tube.
1 - Type 6V6 vacuum tube.

1 - Valpey type 5 crystal, 2979 Kc.: Serial No. 743.
1 - Valpey type CM1 crystal, 3135 Kc.: Serial No. R376.
1 - Valpey type CM1 crystal, R3229 Kc.; Serial No. OI360.

The following tubes were shipped in-place in the modulator power unit:

2 - Type 6C5 vacuum tubes
2 - Type 807 vacuum tubes.

1-5. Plates TR-1 to TR-13 are views showing the construction of the 50-watt Communications Co. equipment.

1-6. The above described equipment was received at the Naval Research Laboratory on November 29, 1940.

METHOD OF TEST

1-7. The equipment, when received, was carefully unpacked and examined. Adequate precautions had been taken in preparing the equipment for shipment and no damage had occurred during transit. With the aid of the loose-leaf instructions furnished, the equipment was placed in commission.

Transmitter and Modulator

1-8. The general construction of the transmitter and modulator units was examined and the components were inspected as completely as possible without resorting to complete disassembly or destruction of the various parts.

1-9. The transmitter was adjusted in accordance with the directions contained in the loose-leaf instructions to operate at the frequencies governed by the crystals furnished. Measurements of power output (carrier power) were made by a lamp load and a photronic cell. Tests were made with a 50 watt, 32-volt

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lamp and also with a 50 watt, 64-volt lamp. A 300 µµf. capacitor was connected in series with the lamp load in each case. A photronic cell, rigidly anchored at a definite distance from the lamp load, and a microammeter were used to determine the power dissipated. A quick acting, low capacity switch was used to transfer the lamp load from the r-f source to a 60 cycle calibrating source in order that the various parts of the load and measuring circuit might be maintained at temperature equilibrium. A precision type wattmeter (Weston Model 310) was used to determine the exact power required to produce the same photronic cell deflection which was obtained from the output of the transmitter. Tests of power output were also performed while using plaque resistors for an antenna load and with the carrier modulated.

1-10. The equipment was placed in a test chamber and subjected to variations in ambient temperature and relative humidity. Another radio telephone receiver was set up outside the test chamber where it could be operated at a substantially constant temperature and was used as a monitoring device for the equipment which was being subjected to variations in temperature and humidity. The transmitter under test was loaded into dummy antenna consisting of a 300 µµf. capacitor in series with a 10-ohm low inductance plaque resistor. Provision was made to check the power output at stated intervals during the course of the various tests conducted in the test chamber. The ambient temperature was varied between the limits of +50°C and -15°C. The relative humidity was varied between the limits of approximately 30% and 95% at a temperature of 40°C.

1-11. The ability of the equipment to withstand pitch, roll, and vibration was determined by mounting the apparatus on a test platform capable of producing these effects in controllable amounts. The equipment under test was kept under constant observation and voice signals were transmitted at stated intervals. These signals were monitored and observed by means of another radio-telephone receiver installed nearby, and listening tests were conducted on the reception of voice modulated signals.

1-12. Tests of audio fidelity and of the modulation capabilities of the equipment were made by applying the necessary audio input signal across a 350-ohm non-inductive resistor which was substituted for the microphone. A model OB Radio Research Company Audio Analyzer Equipment and a cathode ray oscilloscope were used to obtain data on the resulting modulated carrier output.

1-13. The characteristics of the fish-pole antenna furnished were obtained by means of a Q-meter. A substitution method was used. The measurements were performed with 16 feet of lead-in added to the 13-1/2 feet supplied with the

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antenna. With this additional lead, quarter-wave resonance was found to exist at 2500 kilocycles. Information was also secured on the operation of the transmitting equipment with the antenna.

Receiver

1-14. The receiver section of the equipment was examined; first from the electrical viewpoint, with most of the information being derived from the circuit schematic diagram and from accompanying literature; second, from the mechanical and structural viewpoint, by direct visual inspection. The results of these examinations are given in pars. 3-1 and 3-2.

1-15. No comparative listening tests were conducted on this receiver.

1-16. The characteristics of the receiver, as received at the Laboratory, were measured in a shielded room, using a standard signal generator (Ferris, MODEL 16C, SERIAL 44) and a standard dummy antenna (General Radio Type 418G). The audio output was measured by means of an Output Meter (General Radio Type 583A, Serial 67). The sensitivity of the receiver was measured at full gain, since the noise level on loud-speaker operation was very low. A value of signal plus noise output of 40 milliwatts was chosen as being far enough below the AVC threshold point at 30% modulation. Noise output was also measured both with modulation off and carrier off. Selectivity was measured at the same constant output level, with the input frequency varied at different input levels to give the same output reading on both sides of the frequency of maximum response. Image ratio was determined by measurement of the input at the image frequency necessary to give 40 milliwatts output. This value of input was divided by the input for 40 milliwatts output at the desired frequency to give the image ratio. The I.F. response was measured as the input at the I.F. peak frequency necessary to give 40 milliwatts output.

Resonant overload characteristics measurements were made, with inputs from 2μv to 2 volts. Noise level with modulation off was measured at each point. The effect of various carrier modulation percentages was determined in terms of A.F. output at 400 cps. The attenuation of the gain control was measured at the point of minimum output.

The voltage appearing at the antenna binding post due to the receiver oscillator was measured by substitution. The output caused by this undesired voltage in another receiver, coupled to the antenna post of the Communications 66B receiver through 5,000-ohms resistance, was measured. The standard signal generator was then substituted for the Communications

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66B receiver, and the input necessary to give the same output from the measuring receiver was determined. This measurement was made at the fundamental, second harmonic, third harmonic, etc., of the oscillator frequency.

The results of the above measurements are described in par. 3-6-(a to f) and are shown in Plates R-1 to R-5 and Tables R-1 to R-6.

1-17. The equipment was set up in the temperature and humidity chamber, as described in pars. 1-10, 2-18, and 2-19. Since the transmitter output load was left connected to the antenna post of the equipment throughout the temperature-humidity tests, a 5,000-ohm non-inductive resistance was used to isolate the equipments under test from each other, and also to protect the signal generator from the antenna voltage during operation of the transmitter. Changes in gain and noise level were measured during the course of the tests described in the above-mentioned paragraphs and as given in par. 3-7. Results of the tests are shown on Plates R-6 to R-13 and Tables R-7 to R-13.

1-18. The equipment was set up for the vibration and inclination tests as described in pars. 1-11, 2-16, 2-17. The receiver was checked for changes in gain or functioning, with the results given in par. 3-8.

1-19. No receiver frequency measurements were made during the temperature, humidity, and vibration tests, other than the signal generator dial settings, due primarily to lack of time and the unavailability of precision frequency measuring equipment during the test period. However, the signal generator dial settings were found to be satisfactory for frequency changes of the receiver in "TUNE" position. The method for obtaining this frequency was as follows: At the beginning of the test, the variable tuning condenser, in operation in the SHIP-SHORE section of the receiver, was tuned for maximum response at position 1, corresponding to a receiver frequency of 2514 kcs. with a crystal controlled oscillator. Measurements were then taken, and by means of a coupling rod to one of the chamber port holes, the SHIP-SHORE section of the receiver was switched to "TUNE" position, and the same measurements taken. For all subsequent readings, the receiver controls, with the exception of the selector switch, were not disturbed, so that signal generator dial settings at maximum response of the SHIP-SHORE section on "TUNE" position correspond to the changes in receiver frequency on that position during the tests.

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DATA RECORDED

1-20. The data recorded during the tests are shown in the appended tables and plates. Tables and plates with the prefix TR refer to the equipment as a whole; the prefix T refers to the transmitter, while the prefix R covers receiver data.

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SECTION II

TRANSMITTER - MECHANICAL DESIGN AND CONSTRUCTION

2-1. Vacuum Tubes.

(a) The Communications Co. Model 50A transmitter and its accompanying Model 56B speech amplifier-modulator unit employ a total of seven tubes. The tubes in the transmitter are as follows:

(1) One Type 6V6 crystal controlled oscillator,

(2) Two Type 807 tubes connected in parallel which constitute the power amplifier stage.

The speech amplifier modulator unit contains the following:

(3) Two Type 6C5 tubes in push-pull which act as the speech amplifier.

(4) Two Type 807 tubes in push-pull class AB_1.

(b) Of the tubes listed above, only the Type 807 has received Navy type approval, Type 6C5 tubes having been dropped from the approved list except for replacement purposes. The Type 6V6G is approved, but the 6V6 (metal equivalent) which is used in this equipment has not received approval. Two of the 807 tubes received with the apparatus were equipped with "Micanol" bases, while the other 807's had isolantite bases.

(c) All tube sockets in the transmitter and modulator units are of ceramic and are each mounted by two screws which pass through the chassis.

(d) All tubes are mounted in an upright position with the base down. No shock mounting or tube base clamps are provided and, during the vibration test to which the equipment was subjected, the Type 807 PA tubes worked out of their sockets. This was apparently due to the very excessive amplitude of vibration induced in the transmitter unit, for identical sockets in the modulator unit held the 807 modulator tubes satisfactorily. However, clamping means to retain the tubes in position must be provided or the transmitter unit shock mounting modified to prevent the difficulty. The socket contacts grip the base pins of the tubes firmly and provide good electrical contact. The location of the Type 807 modulator tubes allows the glass envelopes of the tubes to strike against the adjacent modulation transformer case, the normal clearance between glass and case being only 1/16 inch. Although the vibration to which the equipment was subjected was insufficient to cause any breakage, trouble may result under service conditions.

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(e) Connection to the tube caps of the Type 807 tubes is made by uninsulated clips. All clips provide firm contact and functioned satisfactorily during the period of test.

(f) The transmitter indicator lamp has its filament connected in parallel with the filament of the 6V6 oscillator tube. This combination is then connected across the 12 volt supply in series with the 6C5 speech amplifier tubes which have their filaments in parallel. With this arrangement, operation of the transmitter after the indicator lamp has burned out results in an overvoltage being applied to the oscillator tube filament. This is a situation which is almost certain to occur in service, and if the indicator lamp is not promptly replaced, the oscillator tube may be damaged. It is recommended that the necessary changes be made to isolate the tube filament and indicator lamp circuits and eliminate all possibility of trouble.

2-2. Panel Controls. The following controls are provided for the operation of the transmitter portion of the equipment.

(a) "On-Off" switch. A SPST nickel-plated toggle switch. The switch lever extends 1/2 inch from the panel. It controls all filament power in the transmitter and modulator units, and, in addition, the dynamotor cannot be started unless the switch is in the "on" position.

(b) "Frequency" switch. This is a four-position, three-section switch having a fluted bakelite knob 1 1/2 inches in diameter extending one inch from the panel. The knob is secured to the flattened shaft by a single set screw. A white dot on the face of the knob serves as an indicator for the four switch positions engraved on the 2" x 3" bakelite switch plate.

(c) In addition to the two controls described above, provision has been made for tuning the PA and antenna circuits by means of variable capacitors. A 4" x 4 1/2" plate must be removed from the front panel of the transmitter in order to make these adjustments. Four 1/2 inch diameter holes concealed by this plate allow the insertion of the required screw driver blade. It is also necessary to withdraw the transmitter chassis from its case slightly in order to loosen the locks on the shafts of the variable capacitors before adjustment is possible.

(d) A transmitter indicator light is provided at the top of the front panel. The jewel is of red glass 1/2 inch in diameter, illuminated by a 6-8 volt, 150 milliampere lamp bulb.

(e) In addition to the controls listed above, a push-to-talk switch is mounted in the handle of the microphone. The button cannot be locked in the "on" position. Operation of the push-to-talk button starts the transmitter dynamotor and actuates the antenna transfer relay.

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(f) All controls are adequate in size and are sufficiently strong to withstand normal operation.

2-3. Tuning. The means provided for tuning the various transmitter circuits are as follows.

(a) Crystal Oscillator. A Pierce crystal oscillator is used which has no provision for tuning. Sockets are provided for four crystals, any one of which may be selected by means of the "frequency" switch described in paragraph 2-2-b. The crystal sockets employed are standard five-hole wafer tube sockets. The crystals may be inserted in any one of three different positions, only one of which is correct.

(b) Power Amplifier and Antenna. Two complete and independent power amplifier tank and antenna tuning circuits are provided. One system is used with the two higher frequency channels (2738 kcs. and 2670 kcs.) and the other with the lower channels (2118 kcs. and 2142 kcs. in the equipment tested). The selection of the proper system is automatically performed by two sections of the "frequency" switch described in paragraph 2-2-b. The PA tank and antenna load coils are wound on isolantite plug-in coil forms which fit standard ceramic tube sockets. The PA coils furnished cover the frequencies for which crystals were supplied, and it was unnecessary to change coils. The plug-in feature is of use only if operation on a different band of frequencies is required. The manufacturer states that the high frequency limit of the unit is approximately five megacycles, due to the fact that frequency multiplication is not used and straight through or fundamental crystals are necessary. No tests were made on the equipment, except at the frequencies of the crystals furnished (2118, 2142, 2738, 2670 kcs.). Tuning of the circuits is accomplished by means of variable capacitors as described in paragraph 2-2-c. Since the range of control available with the antenna tuning capacitors is insufficient to permit resonance with various types of antenna or lead-in, extra plug-in antenna loading coils were furnished. After the equipment is properly adjusted, however, coils need not be changed, and the only operation necessary is the manipulation of the "frequency" switch on the front panel. Meters required for tuning are described in paragraph 2-9-a.

2-4. Accessibility and Protection of Personnel. The transmitter chassis is contained in a cast metal cabinet, and is secured in place by two nickeled screws of the nondetachable variety which pass through the front panel. The chassis may therefore be easily detached from the cabinet and pulled forward sufficiently to allow releasing the variable capacitor shaft lock screws mentioned in paragraph 2-2-c and permit changing the antenna load coils. To remove the chassis from the cabinet entirely, it is ordinarily necessary to remove the antenna connection and ground strap, unless these leads have

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considerable flexibility. The chassis may then be withdrawn completely and all parts become very accessible. Any component of the transmitter may be examined and replaced without difficulty, except the three-section "frequency" switch, which requires considerable disassembly. Although accessible, a few parts are difficult to remove, due to the soldering techniques used. The modulator-power unit is shown in Plates TR-1 to TR-3. Fuses may be renewed by removing a 4" x 4" cover plate held to the side of the speech amplifier-modulator shield with two screws. The entire shield may also be removed by taking out the two screws which hold it. This allows all tubes to be reached for replacement. Access to wiring and all components mounted on the under side of the chassis is obtained by removing the two screws which hold the equipment to the base. Plate TR-3 shows the arrangement of parts under the chassis. Transformers, capacitors, resistors and all other circuit elements are mounted and wired so as to be readily replaced without disassembly. The accessibility of the dynamotor is discussed in paragraph 2-13-g. Interlocks for the protection of personnel are not supplied on any unit, and since potentials up to 600 volts are present in the transmitter unit and at the fuses of the modulator power unit, it is considered that the omission of safety devices offers considerable hazard. However, this voltage is present only with the microphone push-to-talk button depressed. Direct current voltages are entirely prevented from reaching the antenna by means of an .001 mfd. blocking condenser and the use of inductive coupling between antenna and PA tank circuits as well.

2-5. Wiring.

(a) Much of the wiring has been done with varnished braid insulated stranded wire which has been neatly cabled together where possible. RF leads have been made with solid wire with spaghetti insulation, and have been kept separate from leads used for other functions. High voltage leads and the flexible leads to tube cap clips are stranded glass braid insulated wire. Many soldered joints have been protected by an insulating sleeve slipped over them. In general, wiring and soldering has been carefully done, and solder is not depended on for mechanical strength.

(b) The following defects were noted:

(1) Cabled leads are not solidly secured throughout their run. This has resulted in chafing of the insulation of the leads beneath the transmitter chassis, and would eventually cause short circuits or breakage of wires. Suitable cable clamps fastened to the chassis should be used.

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(2) Although all components are quite accessible, several of them cannot be easily removed because solder has been run over the retaining screws.

(3) The metal cases of a .05 mfd. by-pass capacitor and a 4 mfd. high voltage filter condenser have been soldered together, making the replacement of either unit more difficult.

(4) A long unsupported lead is used from the break-in relay contact to the chassis lead-through insulator for the receiver antenna. The lead is subject to vibration, chafing, and possible wire breakage, and it is suggested that an intermediate support be supplied for this lead.

2-6. Insulation. Ceramic material has been used at many points for insulation, namely; sections of the frequency selector switch, all tube sockets, insulation of variable capacitors, antenna posts, plug-in coil forms, stand-off insulators for the support of RF chokes and high voltage terminals, and chassis lead-through insulators for antenna wires. Micalex is used for the insulation of the antenna-transfer relay. Phenolic insulation has been used for insulation in the "on-off" switch, molded cases of mica capacitors, transformer terminal strips, terminal insulation of metal cased by-pass and filter capacitors, and for the support of other low-voltage components, all of which are permitted by Naval specifications. Phenolic insulation has also been employed in the following cases where its use is normally prohibited by Naval specifications: Crystal holders and sockets, support of various units at RF or DC voltages above 500 volts, inter connection cable plugs and sockets, modulation transformer terminal strip, metal cased high voltage filter capacitor terminal insulation, and fuse supporting panel. No trouble of any kind due to the use of phenolic materials in these applications was encountered during the test period.

2-7. Weights and Dimensions. The weights and dimensions of the various units are listed in Table TR-1. It will be noted that the total weight, exclusive of the antenna, is 95 3/4 lbs.

2-8. General Physical Construction.

(a) Separate units are used for transmitter, receiver, and modulator-power supply. The transmitter chassis and front panel are cast in one piece. The case is also of cast construction and completely encloses all transmitter components. The modulator-power unit is also provided with a cast chassis which

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serves to enclose much of the wiring and many of the smaller components. An additional shield of light gage metal is provided to cover the speech amplifier and modulator tubes and transformers. A small removable cover plate in the shield allows fuses to be replaced without disturbing the entire shield. The wall thickness of the metal casting used in the transmitter, receiver, and modulator cases and chassis ranges from 1/8 to 3/16 inch. The auxiliary cover used on the modulator unit is made up of 16 gage sheet metal with welded corners. Chassis, front panel and the cases of all units are of non-magnetic material finished in gray wrinkle on the exterior and with aluminum paint on all interior surfaces.

(b) Steel has been employed in many instances where it has been the practise in Navy apparatus to use other materials. In a few cases the protection against corrosion is insufficient. The threaded assembly rods and nuts of the frequency selector switch are of unprotected steel, as is the notching device spring of the same component. Steel which has been plated, painted or otherwise protected against corrosion is used for applications as follows: shaft of frequency selector switch, "on-off" switch case, microphone and meter jack frames, dial light socket frame, set screw of selector knob, screws and nuts which secure many components, filter and by-pass capacitor clamps, cases, and terminal studs, clips which hold electrolytic capacitor, case and terminals of the dynamotor starter relay, transformer cases, receiver converter shield, parts of the connector cable plugs and receptacles. Metal parts of the Lord mounts on which the units are supported are of cadmium plated steel which shows evidences of rust. In addition, experience has shown that for maximum length of service the use of plated metals is undesirable in this type mount. It is therefore recommended that monel metal be substituted for steel in this application.

(c) No provision for ventilation is made in the units which comprise the equipment. There was no evidence of overheating due to this omission, but overheating attributed to other causes was noted and is described in paragraphs 2-13 and 2-20. The transmitter and receiver dynamotors are mounted externally on top of the modulator-power unit chassis and are of the completely enclosed type.

(d) The equipment is not of drip proof construction.

(e) The transmitter dynamotor is provided with grease packed ball bearings. End bells and retainer screws must be removed before grease can be added. This can be easily accomplished at one end, but the proximity of the receiver dynamotor makes it impossible to remove the dynamotor end bell from the inner end without removing the bolts which secure the dynamotor to the chassis. It is therefore suggested that the components

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of the modulator-power unit be rearranged to permit access to both bearings and all brushes of the dynamotor. Directions as to the type of lubricant, frequency of lubrication, and disassembly necessary should be included in the instruction book.

2-9. Transmitter Components.

(a) Meters necessary for the proper adjustment of the transmitter are not furnished. Two jacks in the front panel are provided for the connection of a 250 milliampere meter to read PA plate current and a 10 milliampere meter to read PA grid current. The jacks are not marked in any manner, and it is suggested that suitable nameplates be added. In addition to the above, a 0-1 or 0-2 ampere RF meter must be inserted in the antenna lead. The modulator unit is provided with a meter jack also, so that plate current through the 807 modulator tubes may be checked.

(b) Switches employed in the transmitter are listed and described in paragraph 2-2. No trouble was encountered in the operation of these switches at low ambient temperatures (-15°C).

(c) Composition resistors are used in 1/2, 1, and 2 watt ratings. All are adequately identified by color coding or other markings. Leads have been used for support with the 1/2 and 1 watt sizes, but all 2 watt resistors are mounted in fuse clips which grasp the resistor in the center of the body. Wire wound resistors are used in all ratings over two watts. None are of the ferrule type, but wiring is not used for support in any case. The smaller wire wound resistors are mounted with fuse clips in the same manner as the two-watt composition resistors, and it is recommended that a protective sleeve of heat resistant material be used between the body of the resistor and the mounting clip to prevent crushing of the insulating coating. All wire wound resistors used in the equipment have a protective insulating coating over the resistance wire.

(d) Fuses are mounted on a bakelite strip on the top of the modulator chassis. A removable access door in the speech amplifier-modulator shield allows access to the fuses without disturbing the main shield. A complete listing of all fuses will be found in Table T-15. Fuse positions are not marked in any way, and confusion in replacing fuses is quite probable in service. It is therefore suggested that permanent and complete markings be supplied to designate the proper fuse to be used in each location. With the exception of the high voltage fuse, all fuses used in the equipment may be replaced by fuses conforming to the Navy standard dimensions listed in specification 17 F 2G. The dynamotor output fuse described in Table T-15 is of a type which has been accepted for use in standard Navy transmitters.

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(e) Fixed capacitors used in the transmitter and modulator-power sections of the equipment include molded bakelite cased mica capacitors, pyranol filled filter capacitors, metal cased paper dielectric filter capacitors, and several metal cased electrolytic capacitors. All are manufactured by Cornell-Dubilier and are standard types. Four variable capacitors are used in the transmitter circuits, all being equipped with ceramic insulation and shaft locking devices to prevent movement due to vibration.

(f) The antenna terminal is situated on the front panel of the transmitter as shown in Plate TR-4.

2-10. Mounting and Shock Proofing.

(a) Each of the three units which comprise the equipment is supported on four #12 Lord mounts, which may be fastened to a horizontal surface. These mounts are secured to the cases of the transmitter and receiver units by a center bolt, which may be removed easily to allow the case to be separated from the mounts. This greatly facilitates the initial installation of the apparatus and permits the rubber mounting to be renewed easily. The center bolts, which secure the mounts to the bottom panel of the modulator-power unit, are soldered and cannot be removed in this manner. The proper installation of the equipment is therefore much more difficult in this case, and the rubber mountings cannot be renewed without considerable trouble. It is suggested that the mounts be secured to the base panel in this unit in the same manner as in the other units. The receiver dynamotor is additionally protected by soft rubber washer supports. Tubes and other components of the equipment are not individually shock mounted. The extent of the protection afforded by the above measures was tested by submitting the equipment to the standard roll and vibration tests. At a vibration frequency of approximately 18 cycles per second, very severe vibration of the transmitter was observed. The amplitude was sufficient to cause the case of the unit to strike the metal part of the Lord mounts. The transmitter ceased to operate within four minutes after the vibration test was started. An inspection revealed that one of the antenna load coils had become dislodged from its socket and its base pins beset by the battering it thereafter received; the other antenna load coil was loose in its socket; and that one of the Type 807 tubes had worked out of its socket as far as the top of the case would allow, and the other PA tube was loose. The movement of the PA tube brought its cap in contact with the case, and thus caused the high voltage fuse to blow. Operation during the inclination test was satisfactory, and no trouble of any kind was noted. It is quite evident from the above that the equipment is incapable of withstanding conditions of vibration which may be encountered in service. Changes must be made in the method of shock mounting to prevent the difficulties noted

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before reliable and safe operation is possible.

(b) The microphone is not provided with any mounting device. An eye with a 5/16" x 1/2" rectangular opening permits the unit to be hung up.

2-11. Microphone. No handset was furnished. Diagrams accompanying the equipment indicate that one can be used by providing an external terminal block. The microphone with which the set is equipped is a "Universal Handi-Mike, Model 200TC, Type: carbon." Five feet of shielded rubber covered cord and a three circuit microphone plug are supplied with the microphone. The handle and head of the microphone are die cast of nonmagnetic metal having a bright finish. The microphone unit itself is set in sponge rubber and is replaceable. It bears the stamped number "648" and a label reading "Universal Microphone, Inglewood, California." The push-to-talk switch in the handle of the microphone is a standard H and H, 3 amp., 250-volt momentary contact switch, and may be replaced without trouble. It was found that screw threads cut in the material from which the die casting was made have little strength, and several of the assembly screws did not hold. The situation may be improved by using a better grade of material, or by using a coarser tap and threading the holes to a greater depth.

2-12. Method of Connection. The receiver and transmitter are each connected to the modulator-power unit by means of shielded rubber-covered cables. A twelve-conductor cable, 12 1/2 feet in length, is used for the transmitter connection, and an eight-conductor cable, 10 1/2 feet in length, for the receiver. Amphenol octal-type connectors are used on cables and units. These connectors have drawn brass cadmium-plated shells with a threaded locking ring to prevent accidental disconnections; the insulation is molded Bakelite. A similar type connector, equipped with heavy duty contacts, is used for the connection between the power unit and battery cable. The battery cable consists of two single-conductor stranded wires five feet in length. The loudspeaker wire is a four-foot twin-conductor rubber covered cable furnished with a standard phone plug for connection to the receiver. The threaded connector locking ring was found to be cross threaded in the case of the battery cable. It is suggested that such parts be inspected more carefully by the manufacturer. The transmitter and receiver units are equipped with ground connection studs on the front panels, and a similar stud is supplied on the chassis of the modulator-power unit. It is recommended that the transmitter ground stud be increased in size to permit a suitable ground lead to be connected more readily, and that the studs be locked in some manner to prevent turning when the connections are tightened.

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2-13. Power Equipment. All power supply components are mounted in the modulator-power unit. The equipment available for test was designed for 12-volt d-c operation. A line switch is not included, but since the battery cable connector plug may be removed easily, this omission will cause no difficulty in service. Two transmitter power circuits are provided, both supplied from the 12-volt line. One of these, fused for 10 amperes, supplies all transmitter and modulator vacuum tube filaments and all relays. The other, which is fused for 50 amperes, supplies the transmitter dynamotor. The input circuits are not equipped with RF line filters. Power to the transmitter dynamotor is applied through a magnetic starter mounted beneath the power unit chassis. The microphone push-to-talk button controls this relay, hence the dynamotor is in operation only while the push-to-talk button is depressed. Name plate data on the transmitter dynamotor will be found in Table TR-2. It will be observed that the high voltage winding is rated at 600 volts and 200 milliamperes. Data taken of the load currents actually observed are shown below. Initially, compromise tuning adjustments were made so that operation on any one of the four channels was possible by manipulation of the frequency selector switch only.

Frequency Kcs.	Line Volts	Dynamotor Output	
		Volts	Amps.
2118	12.1	540	0.290
2142	12.1	555	0.272
2738	12.1	558	0.280
2670	12.1	565	0.255

The above values are those obtained without modulation. Whistle modulation at 2118 kilocyles produced a load of 340 milliamperes at 530 volts. As shown in the name plate data of Table TR-2, the dynamotor is rated for intermittent duty at 200 milliamperes. The data listed above indicates that it is subjected to very serious overloads in this equipment. A standard locked key test for one hour was conducted as shown in Table T-9. No failure occurred in the dynamotor or other components during this period. The temperature rise of the dynamotor casing was recorded during this test, as may be seen in Table T-9, and the same information is presented in graphical form in Plate T-1. A thermometer fixed to the frame of the machine was used to record the temperatures. It is recommended that the necessary changes be made to eliminate overloading of the dynamotor, and that all parts be capable of continuous operation without excessive temperature rise. An examination of the construction of the dynamotor disclosed the following facts.

(a) The high voltage (output) commutator is 3/8 inch wide and is undercut. Two brushes are used, each 1/4" w. x 1/8" t. x 1/2" l. The positive brush is

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marked +101, while the negative brush is marked -114.

(b) Brush holders are of bakelite.

(c) End frames are of cast aluminum.

(d) Grease packed ball bearings are used. End bells and grease retainer caps must be removed in order to add grease.

(e) Terminal strips are not provided; leads are brought through holes in frame.

(f) Cooling of the dynamotor is accomplished by natural ventilation. Totally enclosed construction is employed.

(g) The end bell at the low voltage (input) end of the transmitter dynamotor is very close to the receiver dynamotor housing, and cannot be removed for inspection of the brushes, commutator, and bearing without removing the bolts which secure the transmitter dynamotor to the chassis. (This difficulty is also discussed in paragraph 2-8-e)

2-14. Antenna. A fish-pole type antenna was furnished with the equipment. This consists of a 33 foot bamboo pole 1 3/4 inches in diameter at the base and tapering to about 1/2 inch at the top. The antenna wire is wound around the pole and then covered with wound layers of varnished cambric to produce a longer electrical length than the actual physical length of the pole. The manufacturer states that the antenna supplied is 1/4 wavelength long at 2738 kcs. During tests conducted at the Laboratory, it was necessary to extend the 13 1/2 foot lead-in, with which the antenna is equipped, to a total of 29 feet. Plate T-2 shows the measured characteristics of the antenna when used with the lead. It may be noted that quarter wave resonance occurs at 2500 kcs. A section at the base of the antenna pole four feet in length is not wound with antenna wire or cambric. This section may be used for lashing the pole to the mast or to some other suitable support. Mounting brackets are not supplied. From an examination of the antenna, it was concluded that its strength would not prove adequate under conditions where icing might occur.

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OPERATIONAL DATA AND TESTS

2-15. Power Output and Operation into an Actual Antenna. Tables T-1, T-2, T-3, and T-4 give the results obtained from power output tests conducted on the Model 50A transmitter. These differ chiefly in the method of tuning used and the type of dummy load. Table T-1 shows the outputs obtained into a 50-watt, 32-volt lamp load after adjusting for maximum output on each frequency. The data listed are for carrier only, i.e., no modulation, and it may be observed that the RF output was from 32 to 39.4 watts, depending on frequency. As pointed out in Notes 1 to 4, these represent maximum outputs obtained immediately after the carrier was turned on. On each band, an observation after about three minutes operation showed that the power output had dropped from 10 to 25%, due to the heating of circuit elements. Table T-2 shows data obtained when using the same antenna, but with the equipment adjusted so that operation on any one of the four channels was possible by manipulation of the frequency selector switch only. Output without modulation, and before appreciable heating of circuit elements occurred ranged from 27.4 to 36.3 watts. Another test was made, using a 50-watt, 64 volt lamp load, as may be seen in Table T-3. The transmitter was tuned for maximum output on each channel, and the power output was measured with and without modulation. Carrier power did not differ appreciably from that obtained with the lower resistance, 32-volt lamp, and outputs between 36.2 and 37.2 watts were observed. The same table also shows the total power output of the transmitter with substantially complete modulation. The measured power in this case was from 50.8 to 52.3 watts. In Table T-4, a resistance, rather than a lamp load, was employed. The results of the test, however, are quite similar to those of Table T-3, and no appreciable improvement in output or operation was noted. The manufacturer has assigned a rating of 50 watts to the Model 50A transmitter. From the above data, it is apparent that the measured output fails to attain this value, except in those cases where side band power is included in the total power output, which is not customary. Table T-5 shows data obtained when operating the transmitter with the fish-pole antenna furnished with the equipment (See par. 2-14). The antenna was equipped with a lead 13 1/2 feet in length, but the condition of installation at the point of test required the lead to be extended to a total of 29 feet. Plate T-2 illustrates the measured characteristics of the antenna and lead. Since it was impossible to mount the antenna entirely in the clear, some modification of these characteristics may be anticipated in actual practise. Table T-5 shows that when individual adjustments were made for each band, about 33 watts could be obtained on the ship-shore channels and 52 watts on the ship channels. With the equipment tuned so that no tuning other than manipulation of the frequency selector switch was necessary, the output dropped to 28 watts on the low frequency channels and 40 watts on the high frequency

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channels, owing to the compromise tuning necessary. This, of course, is the normal condition of operation. It was found that adjustment of the PA and antenna tuning circuits was too critical to permit the choice of the best compromise setting to be made easily. Less critical circuits or individual adjustment for each frequency should be provided.

2-16. Inclination Test. The Model 50A transmitter and Model 56B modulator-power units were subjected to a standard inclination test, results of which are shown in Table T-6. Both front-to-back and side-to-side inclination were performed. The transmitter was in operation only while readings were being made during this test, or about 25% of the time. The operation of the transmitter was checked at intervals throughout the test and the quality of the output observed at frequent intervals on another radiotelephone receiver. No difficulty of any kind was encountered, all relays performed satisfactorily, and the quality of transmitted speech was found to be unaffected by the conditions imposed by the test. Due to the low overall height of each unit, excessive movement of the units was not apparent, in spite of the flexibility of the shock mounts, which are used for support.

2-17. Vibration Test. The transmitter and modulator units were secured to a horizontal surface by means of the shock mounts provided, and subjected to vibration between 10 and 30 cycles per second. Very severe vibration appeared in the transmitter unit, and at about 18 cycles the amplitude was so great that the bottom of the case struck the metal portions of the shock mounts. The transmitter stopped operating within three minutes from the start of the test. Investigation revealed that one load coil had been dislodged from its socket and damaged, and that the other load coil was loose. Also, one Type 807 PA tube had worked out of its socket far enough to short the tube cap clip to the case, which resulted in a blown high voltage fuse. It is apparent that changes must be made in the shock mounting and construction before satisfactory service is assured. These changes may include the substitution of "stiffer" rubber mountings for the unit, elimination or improvement of the plug-in coil feature, and the addition of clamps to retain tubes in their sockets. The equipment did not remain in working order long enough to observe the effect of vibration or the quality of modulation.

2-18. Variation of Ambient Temperature. Table T-7 shows information obtained during the course of this test. It will be noted that after an initial period of 1 1/2 hours at 50°C., the ambient temperature was dropped to -15°C., where it was maintained for the remainder of the test. During the first hour and a half period (at 50°C.), the transmitter was on just long enough to enable readings to be made. The equipment was then shut down, and remained idle for three hours and twenty-

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five minutes, which included an hour and a half at -15°C. At the end of this time, an inspection of the equipment, and especially the controls, was conducted and the transmitter was restarted. The last section of the test was made in the same manner as during the first period, with the transmitter operating only while readings were being made. An examination of the data shown in Table T-7 reveals no serious changes in output or other values as a result of the 65°C. temperature change. The equipment could be restarted and operated without difficulty at the lowest ambient temperature attained. The quality of the transmitter output signal was observed on another radiotelephone receiver, and appeared to be unaffected by the temperature.

2-19. Variation of Humidity. Two humidity tests were conducted on the Communications Co. equipment, the results of both being shown in Table T-8. The first half of these tests closely follows the procedure employed in testing standard Navy transmitters. With the temperature maintained at 40°C., where it was held throughout the entire test, the equipment was first stabilized under conditions of low relative humidity. The humidity was then increased and held between 90 and 97 per cent for one hour, after which it was decreased to below 30 per cent, and the equipment again stabilized for one hour. This completed the first part of the run. An examination of the data contained in the table will reveal no serious changes in output, or other functions, during the period of high humidity from the same values observed during the stabilizing periods at low humidity which preceded and followed it. The transmitter performed satisfactorily at all times. During the test, the transmitter was not in continuous operation, but was on only long enough to enable readings to be taken. The second half of the test immediately followed the first. Its purpose was to investigate the ability of the equipment to perform after an idle period under high humidity conditions. Reference to Note 3 of Table T-8 will show that this was accomplished by raising the relative humidity to between 90 and 97 per cent with the entire equipment shut down, and maintaining this state for 2 1/2 hours. At the end of this time, the transmitter was started and its performance checked against that observed under the low humidity conditions existing previous to the test. The operation of the transmitter was found to be satisfactory and, as shown by the data contained in the table, no serious changes occurred in circuit currents or output.

2-20. Locked Key. Table T-9 shows data collected during a test, in which the transmitter was operated under locked key, full power output conditions for one hour. This test was performed in an ambient temperature of 19.5°C., and no modulation was used. Reference to the table will reveal that considerable change occurred in several of the factors listed. After the first reading, the line voltage remained fairly steady. However, decreases in PA current, RF current, RF output, and dynamotor

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output voltage were recorded during the rest of the test. It has been previously pointed out in paragraph 2-13 that overheating of the transmitter dynamotor was observed. Table T-9 lists dynamotor output voltage and the temperature of the frame during the locked key test. The temperature rise is also plotted in Plate T-1. The test was conducted without modulation; hence, an even greater degree of overheating is to be expected if modulation were used. It has also been pointed out in paragraph 2-13 that modulation increases the dynamotor load as much as 17 per cent. Overheating was also observed in the PA tank coils. Severe heating was confined to a relatively small portion of the coil where the antenna circuit coupling coil is wound over the PA tank winding. During the locked key run, the heat developed was sufficient to cause the insulating compound with which the coils are coated to drip from the coil forms. A d-c resistance measurement was made with a General Radio Type 487-A Megohmmeter of the resistance between the PA and antenna coils. The cold resistance was found to be 30,000 to 40,000 megohms, while the hot resistance was 500 megohms. Q measurements were also made of the capacitance existing between the antenna coil and PA coil, which are wound on the same form. The coils are wound on an isolantite form with cotton covered wire, coils being separated by several layers of cloth tape. The measurements were made at room temperature. The capacitance between coils was found to be 60 μμf with Q = 13.6 at 2700 kcs. in the coil group used for the intership bands. Corresponding values of C = 60 μμf., and Q = 12.8 at 2150 kcs. were found for the coil group used for ship-shore communication. The capacitance between coils is effectively in parallel with the 325 μμf. variable antenna tuning capacitor. The Q measurement indicates that the dielectric between coils is of very poor quality, and the RF current which passes through this mutual capacitance may be the main contributing factor in the heating which was observed to have developed. It is suggested that a coil design which avoids the above difficulties be adopted by the manufacturer.

2-21. Percentage Modulation and Harmonic Distortion. Table T-10 presents data on the distortion introduced by the speech amplifier, modulator, and transmitter at various modulation levels. The 400-cycle audio input signal was applied across a 350-ohm non-inductive resistor which was substituted for the microphone. The distortion was below 11.1% at all degrees of modulation at which measurements were made. Modulation was found to be somewhat unsymmetrical, and the data shows that carrier shift was present. The quality and clarity of transmitted speech were observed by means of a receiver, and were found to be quite satisfactory, with very little background noise. The modulated carrier was also examined directly by using a cathode ray oscilloscope. It was noted that rather severe overmodulation was produced, with attendant distortion, when speaking slightly louder than normally into the microphone.

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The quality of the received signal, however, did not appear to suffer appreciably by this action.

2-22. Audio Frequency Characteristics. Table T-11 presents data obtained on the audio frequency characteristic of the transmitter from the microphone transformer to the carrier. The audio input signal was introduced in the same manner as described in paragraph 2-21, and was held constant at 0.22 volts at all times.

2-23. Break-in. Break-in operation is accomplished by means of a send-receive relay mounted on the under side of the transmitter chassis. The relay is quite accessible for servicing operations, since the entire chassis may be easily removed from the cabinet. The relay is actuated by the push button on the microphone and receives its coil energy directly from the 12 volt supply. The transfer relay acts to switch the antenna from receiver to transmitter, and also has contacts which control the starting relay for the transmitter dynamotor, and a relay which cuts off plate potential to the receiver. Operation of the break-in system was found to be satisfactory at all times.

2-24. Transmitter Control. The Communications Company equipment is designed for local control. Additional handsets or microphones and loudspeakers may be attached, but changes in transmitting and receiving frequencies and adjustment of volume must be performed at the panels of the main equipment.

2-25. Power Required from Supply Lines. Table T-12 lists the total input to the Communications Company equipment under several different conditions, including starting. A total of 308 watts input is required when the transmitter is delivering its full power without modulation.

2-26. Antenna Short-Circuited and Open-Circuited. Table T-13 shows the results obtained when the antenna was shorted and also when the antenna was disconnected. The transmitter was initially tuned up so that operation on any band was possible by manipulation of the frequency selector switch only. It may be noted that in nearly every case the resultant PA current was high enough to cause excessive plate dissipation.

2-27. Vacuum Tube Operating Conditions. The electrode voltages applied to the various tubes of the transmitter and modulator circuits were measured with the results tabulated in Table T-14. The PA plate voltage was found to be 515 volts, which is in excess of the 475 volt rating of the Type 807 given by the tube manufacturer for this class of service. This will result in shortened tube life and decreased reliability. It is suggested, therefore, that the tube overloads now existing in

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the transmitter be eliminated. All other tubes operate within the limits specified by the tube manufacturer.

2-28. Instruction Book. No instruction book was furnished with the equipment. Loose-leaf sheets giving a brief description of the circuits and the necessary procedure for setting up the apparatus were supplied. Circuit diagrams of all units and interconnection required were also supplied. It is recommended that an adequate instruction book be supplied which gives a detailed explanation of all circuits, and includes operating procedure, servicing and maintenance, and schematic diagrams. A complete parts list should also be supplied.

2-29. Spare Parts. No spare parts accompanied the Communications Company equipment, with the exception of a complete set of fuses. Since numerous components are of such design and manufacture that they are not likely to be available within the Naval organization, it is deemed advisable that some definite provision be made to permit repairs by operating personnel. Many of the parts used would fail to comply with Navy standards, and hence disruptions and failures under the rigors of Naval service will undoubtedly occur. It is suggested that the manufacturer be consulted to determine which parts are most subject to failure, based on service records of the equipment.

2-30. Summary of Defects and Suggested Changes. Such items as appear definitely defective together with suggestions for improvement and modification are listed below. At the end of each of the statements there appears the paragraph number in the body of the report wherein each item is discussed in detail.

(1) Types 6C5 and 6V6 vacuum tubes are not Navy type approved. (2-1-b)

(2) The Type 807 modulator tubes can strike the modulation transformer case, which may cause breakage. (2-1-d)

(3) Use of indicator lamp in parallel with the 6V6 filament is undesirable. (2-1-f)

(4) Frequency switch control knob has only one set screw. Two should be used. (2-2-b)

(5) Crystals may be inserted incorrectly. (2-3-a)

(6) The three-section "frequency" switch cannot be replaced without considerable disassembly. (2-4).

(7) Interlocks for the protection of personnel are not included, and warning nameplates are not provided. (2-4)

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(8) Cabled leads are not solidly secured throughout their run; solder has been run over the retaining screws of some components, making their removal difficult; metal cases of filter capacitors are soldered together. (2-5-b)

(9) Phenolic insulation has been used in applications where normally prohibited by Naval specifications. (2-6)

(10) Steel has been used where trouble may develop due to corrosion. (2-8-b)

(11) Metal parts of Lord mounts are of plated steel. (2-8-b)

(12) Lack of adequate ventilation contributes to overheating of component parts. (2-8-c)

(13) Drip-proof construction has not been provided. (2-8-d)

(14) Dynamotor end-bell cannot easily be removed for normal servicing. (2-8-e)

(15) Meters necessary for the proper adjustment of the transmitter are not supplied. (2-9-a)

(16) Meter jacks are not marked. (2-9-a)

(17) Wire wound resistors are mounted in such a manner that the insulating coating may be crushed. (2-9-c)

(18) Fuse positions are not marked with required fuse ratings. (2-9-d)

(19) Shock mounts of the modulator-power unit cannot be replaced without considerable difficulty. (2-10-a)

(20) Shock mounting of transmitter is not effective; tubes and coils became dislodged during vibration. (2-10-a) (2-17) (2-1-d)

(21) Suitable microphone mount is not provided for storage of microphone when not in use. (2-10-b)

(22) Screw threads in the cast microphone case have very little strength. (2-11)

(23) Locking ring on cable connector was cross-threaded. (2-12)

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(24) Transmitter ground stud too small and not locked to prevent turning when connection is tightened. (2-12)

(25) Transmitter dynamotor is subjected to serious overloads. (2-13)

(26) Antenna mounting brackets or other devices are not supplied; antenna may not be sufficiently strong to withstand icing. (2-14)

(27) Measured power output is less than manufacturer's rating. (2-15)

(28) Adjustment of PA and antenna circuits is too critical to permit necessary compromise tuning to be performed easily. (2-15)

(29) Overheating was observed in PA tank coils. (2-20)

(30) Modulation is unsymmetrical and some carrier shift is produced; overmodulation is present under certain conditions. (2-21)

(31) Opening or shorting antenna lead results in PA tube overload. (2-26)

(32) Type 807 PA vacuum tubes are operated in excess of rating. (2-27)

(33) No instruction book was furnished. (2-28)

(34) No spare parts are provided with the equipment. (2-29)

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SECTION III

RECEIVER SECTION OF EQUIPMENT

3-1. Electrical Inspection: The equipment was given an electrical inspection and the following information obtained, in large part, from the schematic diagram and accompanying instructions.

(a) Type of Circuit: Two separate superheterodyne sections, each containing a radio-frequency amplifier, converter, intermediate-frequency amplifier, and detector, feed the same noise squelching and audio amplifier stages. One superheterodyne section is used for fixed frequency (crystal-controlled oscillator) operation on one frequency (INTERSHIP); the other (SHIP-SHORE) is used for operation on any one of four fixed frequencies (crystal-controlled oscillator) or for variable receiver tuning (self-excited oscillator). Either or both sections may be used at the same time, switching being accomplished in the cathode circuit of each r-f amplifier. The same antenna is used for both sections as described in par. 3-1-j below.

(b) Frequency Range: On SHIP-SHORE, TUNE position, the frequency range is approximately 1650 to 3260 kcs., continuously variable. Also available on SHIP-SHORE operation are four fixed frequencies (crystal-controlled oscillator) ranging from approximately 2500 to 2700 kcs. On INTERSHIP, only one frequency, 2738 kcs., is obtainable.

(c) Crystals: Crystal oscillator control is available at each of the five fixed frequencies.

(d) Crystal Mounting: Separate holders are used for each receiver crystal. The crystals supplied with the equipment are mounted in both horizontal and vertical positions with Valpey holders Types 5 and CM1.

(e) Total Number of Tubes: 9.

(f) Tube Types Used: 6S7, 6K8, 6V6, 6SQ7, 6SF5. At the present time, none of these tubes are Navy approved types, and the 6K8 is approved only for replacement purposes

(g) Power Supply Required: 12-v. d-c at about 8.5A. for stand-by power. (Also available for 6-v. d-c and 32-v. d-c operation)

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(h) Type of B Supply and Maximum B+ Voltage at the Receiver: Dynamotor supply - 275-v.

(i) Antenna Required: No type of antenna is mentioned in the literature, other than the Communications Co. fish-pole antenna. (See par. 2-14)

(j) Antenna Input Circuit: For each section of the receiver, there is a single tuned circuit in the secondary of the radio-frequency input transformer, the primaries of which are in series through a 250 μμf condenser. Antenna and ground are connected to the ends of this series circuit, the antenna connecting to the SHIP-SHORE primary.

(k) Radio-Frequency Amplifier: For each section of the receiver, there is one stage of radio-frequency amplification consisting of a 6S7 tube transformer-coupled to the mixer with a tuned circuit in the secondary of the transformer.

(l) Radio-Frequency Tuning: No tuning is necessary for the INTERSHIP section which is pre-tuned. The radio-frequency circuits of the SHIP-SHORE section are continuously variable on the panel dial. With the selector switch on TUNE position, the oscillator is continuously variable on the same dial. With the selector switch on any of the numbered positions, the oscillator is not continuously variable, but is crystal controlled. In any of these positions the radio-frequency circuits must be tuned by ear for maximum response.

(m) Converter: The hexode sections of the 6K8's are used for frequency conversion for both INTERSHIP and SHIP-SHORE reception.

(n) Oscillator: The oscillator for INTERSHIP or SHIP-SHORE operation on any of the fixed frequencies consists of a simple crystal-controlled oscillator utilizing the triode sections of the 6K8's. On SHIP-SHORE, TUNE position, the oscillator is a triode tickler circuit using the SHIP-SHORE 6K8 triode section. The oscillator frequency in all instances is higher than the receiver frequency.

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(o) Intermediate-Frequency Amplifier: Each section of the receiver has one stage of intermediate-frequency amplification using a 6S7.

Tuning frequency = 465 kcs. for SHIP-SHORE
Tuning frequency = 491 kcs. for INTERSHIP
For each section,
Two transformers = 4 tuned circuits

(p) Second Detector: The second detector is a conventional diode detector circuit, with one plate of the 6SQ7 diode section being used for INTERSHIP, and the other plate used as a detector for SHIP-SHORE reception.

(q) AVC System: D.C. from the detector diodes is fed to controlled tubes. Tubes on control in both sections of the receiver = R.F. amplifier, converter, and I.F. amplifier.

(r) C.W. Oscillator: None.

(s) Noise Suppressor: The noise suppressor is of the noise gate type, using the 6SF5 triode in conjunction with the 6SQ7 triode section.

(t) Audio-Frequency Amplifier: First stage = 6SF5 triode resistance coupled to second stage = 6V6 output pentode. Both stages are common to both sections of the receiver.

(u) Audio Output Circuit: An output transformer with a 500 ohm secondary, feeds either the speaker or headphones. It was found that a termination of 1,000 ohms gave .5 db greater output when the standard output of 40 mw. was obtained.

(v) Gain Control: The r.f. gain control of both sections is controlled by varying the cathode-biasing resistor of the radio-frequency amplifier tubes. Separate r.f. gain controls are used for each section of the receiver. The audio volume is controlled by an audio volume control, which is common to both sections of the receiver, and which varies the input to the grid of the 6SF5 first audio stage.

(w) Safety Devices: None are evident.

(x) Changeover Means: The push-button in the handset actuates power and antenna transfer relays.

(y) Remote Control: None is furnished with the equipment.

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(z) Miscellaneous: Both SHIP-SHORE and INTERSHIP sections can be operated simultaneously, allowing reception on two different frequencies at the same time. Operation of the receiver requires switching bands (on SHIP-SHORE) and tuning the r-f amplifier (and oscillator if on TUNE) with the continuously variable control. Both noise gate, labelled "Q", and volume controls are common to the INTERSHIP and SHIP-SHORE sections. The jack on the front panel is used for insertion of either headphones or speaker plug.

3-2. Mechanical Inspection. The equipment was given a mechanical inspection and the following information obtained.

(a) Number of Units Comprising Equipment: 3 in addition to a speaker in separate cabinet.

(b) Weight: Shown in Table TR-1.

(c) Size: Shown in Table TR-1.

(d) General Type of Construction: The receiver chassis is contained in a cast metal cabinet (apparently sand-cast) and is secured in place by two nickeled screws of the non-detachable variety which pass through the front panel, similar to the transmitter chassis. Paragraphs 2-8-a,c, and d also apply. The loudspeaker cabinet is of light gage metal and is not of cast construction, and is of ferrous material.

(e) Number of Front Panel Controls and Function: 9.

1. SHIP-SHORE SENSITIVITY -- This control changes the gain of the radio-frequency amplifier stage.

2. INTERSHIP SENSITIVITY -- This control functions the same as the preceding control.

3. SHIP-SHORE ON-OFF Switch -- This switch opens the cathode circuit of the radio-frequency amplifier stage and controls power to an indicator light which is on when the ship-shore section is functioning.

4. INTERSHIP ON-OFF Switch -- This switch functions the same as the preceding switch.

5. RECEIVER Variable Tuning Dial -- This dial tunes the oscillator and r.f. circuits on SHIP-SHORE TUNE OPERATION and tunes the r.f. circuits on SHIP-SHORE crystal controlled oscillator positions. It does not function in the INTERSHIP section of the receiver.

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6. FREQUENCY SELECTOR Switch for SHIP-SHORE Operation -- This switch has five positions. The first position, labelled "TUNE", is for variable tuning operation, and the other positions, numbered 1 to 4, are for fixed frequency operation by means of a crystal-controlled oscillator.

7. VOLUME CONTROL -- This control is a potentiometer which varies the audio input to the first audio-frequency stage.

8. "Q" (noise gate) CONTROL -- This control sets the level for noise squelch operation.

9. Receiver ON-OFF Switch -- This switch controls power to the receiver power unit.

The switch used to choose INTERSHIP or SHIP-SHORE operation and the variable tuning condenser are not marked to show their function.

(f) Other Controls: The push-button on the microphone controls antenna and power transfer relays.

(g) General Layout and Accessibility of Controls: The layout of controls is symmetrical, and accessibility is good.

(h) Ease of Control and Operation: The use of 9 controls makes receiver operation complicated as compared to similar equipment under test.

(i) Accessibility for Servicing: Good. The receiver chassis may be removed by unscrewing two screws on the front panel. The power cable does not interfere with this operation. All tubes, crystals, and adjustments are accessible in this position. See paragraph 3-2-j for accessibility for repair.

(j) Accessibility for Repair: Poor. Many resistors and condensers are mounted along the outside and inside of three waxed linen bakelite tubes, which are mounted under the chassis, each as a single unit together with an octal tube socket used for tubes in the receiver. While providing a good mounting, the replacement of a resistor or condenser in such a unit would involve disturbing many components, and is difficult. One paper condenser unit in a metal can is difficult to replace without disturbing the tuning condenser mounted on the chassis above it. In some instances, soldering has made the removal of nuts very difficult without first removing the solder.

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(k) Power Indicator: The markings of the ON-OFF switch, and the pilot lamp illuminating the tuning dial, serve as power indicators.

(l) Materials Used and Finishes: All chassis parts and cabinet are of a non-ferrous aluminum alloy, painted with a gray-wrinkle finish on the exterior, and are covered with a gray lacquer on the interior. The loudspeaker cabinet is ferrous, but painted in the same manner as the cabinet. The phone jack, condenser cans, audio transformer case, Lord mounts, washers on the cable plug on the receiver panel, tube socket mounting flanges, and many screws and nuts are ferrous, but plated as a corrosion protective measure. The tuning condenser-plates and shaft are of a cadmium-plated brass. The potentiometers have ferrous covers which show signs of corrosion. (See par. 2-8-b)

(m) General Insulation to Moisture: Appears good, except as noted in paragraph 3-2-cc.

(n) General Protection Against High Temperature: Paragraph 2-8-c applies.

(o) Ability to Withstand Vibration and Shock: A few long leads can oscillate with vibration. Four Lord mounts are used for mounting each unit, the loud-speaker being provided with no means for mounting. There is no provision for locking the tuning dial, which might rotate with vibration. The dial light is in a very poor type of socket, which is mechanically loose. Self-tapping screws are used on the loudspeaker cabinet. These screws might loosen with vibration. The two inter-section plates on the tuning condenser are loose and can oscillate with vibration. A self-tapping screw is used on the tuning condenser to secure the spring contacts wiping on the shaft. This screw might loosen and come out after a period of vibration.

(p) General Ruggedness: Appears good, except as noted in paragraph 3-2-o.

(q) Tube Mounting, Sockets, Etc.: Tubes are vertically mounted in both plastic and waxed bakelite-wafer type sockets, which are part of the bakelite-cylinder type mounting described in paragraphs 3-2-j and (aa). These tubes are the 6K8 converters of both sections, and the 6SF5 audio tube. In almost every instance, tube sockets are difficult to replace, due to wiring. Proper tube designations are painted on the chassis next to the tube sockets, but this paint shows signs

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of wearing off. Tube sockets are not of the Navy standard type.

(r) Tube Shields: None; metal tubes are used throughout.

(s) Transformers, Chokes, Etc.: One audio transformer with unknown potting is used in the receiver. This transformer is easily replaced. One Thordarson choke in the power supply is not completely metal-encased. Overheating of the transformer when a condenser failed caused a loss of wax. (Par. 3-2-x) The output transformer is inadequately protected by paper, and is open between windings.

(t) Crystal Mounting: Each receiver crystal is mounted in a separate holder. Two types of holders are used, one with the crystal horizontal, and the other with the crystal vertical. The INTERSHIP crystal holder has a clamp securing it into its socket. All holders are of the two-pronged type, plugging into 5-prong moulded plastic sockets similar to those used for the tubes of the receiver. No markings are evident on the sockets to indicate into which holes the crystal holder should be inserted. The chassis near each socket is marked with a number corresponding to each of the four numbered positions of the SHIP-SHORE frequency selector switch. No designations are used to indicate the socket for the INTERSHIP crystal holder. The paint used to mark the numbers near each socket shows signs of wearing off. The clamp on the INTERSHIP crystal holder interferes with removal or replacement of the receiver chassis into the cabinet.

(u) R.F. Transformer Structure: Units are in aluminum cans, some not easily accessible, due to solder interfering with the removal of nuts. Replacement of all would involve considerable difficulty. The coils are permeability tuned, and have bakelite insulation and a protective dip against moisture.

(v) I.F. Transformer Structure: Units are in aluminum cans and are permeability tuned. The coils are wound on a paper form and have a protective dip against moisture. Some cans are not easily accessible, due to solder interfering with the removal of nuts, and replacement would involve considerable difficulty. The adjustment screw of one of the I.F. transformers in the grid circuit of the INTERSHIP 6S7 I-F stage was mutilated as received.

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(w) Variable Condensers: One three-ganged condenser is used for tuning. The rotor has spring type wiper contacts on the end section, which are held in place by a self-tapping screw. The shaft and plates are of cadmium plated brass, and plates are soldered to the shaft. Two inter-section shields are on the condenser base, and one has worked so loose that it can vibrate and rotate. The insulation is apparently of porcelain.

(x) Fixed Condensers: No paper tube condensers are used. In the receiver there are four units, each containing three 0.1 µfd paper condensers, enclosed in metal cans, easily accessible, except for the one which is difficult to replace without removing the tuning condensers; many mica condensers in moulded bakelite cases; and one unit containing three 8 µfd electrolytic condensers in a metal can, used for cathode by-passing. One unit containing two 8 µfd - 450 volt electrolytic condensers in a can is used in filter of the power supply.

Soon after being put into operation, one condenser (from the plate of the 6V6 output tube to ground. Cornell Dubilier Type 4L -.1µµf 1000 volt, D.C.)

(y) Switch Construction: Toggle switches are all of the laminated bakelite insulation type. The frequency selector switch is of bakelite-wafer construction, with silver plated "spoon" type contacts.

(z) Resistors: 1/2, 1, and 2-watt resistors are used, many difficult to replace, due to the cylinder type of mounting.

(aa) Terminal Strips: One strip of waxed linen bakelite with creepage path greater than 1/8" is used. Three waxed linen bakelite cylinders are used for mounting most resistors and condensers. These cylinders are 2 1/4" long, 1" inside diameter, and have walls 1/16" thick. The top of the cylinder is a tube socket, with the terminals on the cylinder. The resistors and condensers are mounted inside and outside along the wall of the cylinder, such that creepage paths are about 1/4". The power supply has a bakelite terminal strip with creepage paths greater than 1/8". Terminals on some crystal and tube sockets that are not connected to crystal holder or tube prongs are used as terminal strips for wiring and components.

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(bb) Mounting of Components: Screws, nuts, and lockwashers are used throughout. Most resistors and condensers are mounted as described in paragraph 3-2-aa.

(cc) Wiring: Wire with an impregnated celanese outer wrap and fabric inner wrap, and spaghetti-covered solid wire is used extensively for r.f. circuits. Power circuits use mostly wire with an inner synthetic wrap and a lacquered fabric outer wrap. One braid shield is used, covering two leads. The wiring is placed along the chassis in many instances and is considered poor because of leakage that might develop under conditions of high humidity. A few long leads can oscillate with vibration. Soldering is considered poor. One of the leads on the frequency selector switch in TUNE position was apparently held on to the switch by rosin and came off at the end of the temperature and humidity tests, as did another lead from the INTERSHIP antenna transformer to the .00025 µfd antenna condenser at the same time. The other lead on the frequency selector switch on TUNE position came off after the vibration test.

(dd) Miscellaneous: The antenna terminal on the receiver is connected externally by wire to the transmitter.

The speaker is in a separate cabinet, connecting to the jack on the receiver panel. Headphones may be connected to this jack, instead of the speaker. Self-tapping screws are used on the loudspeaker cabinet. No provision is made for mounting the speaker cabinet.

The loudspeaker or headphone jack is not a Navy standard type and is of cheap construction. Its function is not designated on the front panel.

A cable of six conductors with an octal plug at one end and a six-pronged socket at the other is used for electrical connection between power supply and receiver. Paragraph 2-12 applies.

3-3. Examination of Instruction Book: Paragraph 2-28 applies.

3-4. Spare Parts: Paragraph 2-29 applies.

3-5. Listening Tests: No comparative listening tests were conducted on this receiver. The receiver output was monitored on speech modulation before and after the vibration test, and during the inclination test.

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3-6. Laboratory Measurements. The receiver section of the Communications Co. equipment was measured in a shielded room, (as per par. 1-16), with the following results:

(a) Sensitivity, Noise Output, Image Ratio, and I.F. Response. The sensitivity of the Communications Co. 66B receiver is lower than similar equipments under test. It was noted that at conditions for standard output (40 mw.) there was a 2.7 db. drop in sensitivity of the INTERSHIP section when the SHIP-SHORE section was operating simultaneously, than when the INTERSHIP section was operating alone. Under conditions of operating with a real antenna, the sensitivity with both sections on, as determined by a signal to noise ratio, at maximum sensitivity and minimum noise gate effect, will be less for each section than with either section operating alone, due to the increased noise level.

The intermediate frequency of the SHIP-SHORE section is 465 kcs. and 491 kcs. for the INTERSHIP section. The results of the tests are shown in Table R-1.

(b) Selectivity. The selectivity characteristics of the receiver are shown on Plate R-1. Tabulations R-2, R-3, and R-4 summarize these characteristics.

(c) Resonant Overload and Carrier Noise. The resonant overload characteristics are shown in graph form on Plates R-2, R-3, and R-4. The data for Table R-5 have been derived from these graphs.

Acoustical feedback was encountered quite often with the loudspeaker, at high gain, requiring isolation of the loudspeaker from the receiver.

(d) Effect of Modulation Depth on Output. Plate R-5 shows the effect of varying the signal modulation depth on the audio output from the receiver. The curves depart from linearity above from 50 to 60% modulation.

(e) Gain Control Range. The maximum attenuation of the sensitivity control of the SHIP-SHORE section of the receiver is about 85 db. The maximum attenuation of the sensitivity control of the INTERSHIP section of the receiver is about 68 db. The maximum attenuation of the A.F. volume control is over 86.5 db.

(f) Radiation of Oscillator Frequency. The voltages appearing at the antenna terminal due to the receiver oscillators were measured in terms of the microvolts

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input from a standard signal generator required to give the same output from a receiver tuned to the oscillator frequency. Both the receiver under test and the standard signal generator were connected, in turn, to the input terminals of the measuring receiver. The receiver was tuned for maximum response at the receiver frequency, with gain controls at maximum. The resulting data is given in Table R-6. With the INTERSHIP section in operation, the INTERSHIP oscillator can be received in the SHIP-SHORE section on TUNE as a signal.

3-7. Temperature and Humidity Tests. The equipment was set up in the large Temperature-Humidity chamber and was tested under the conditions described in paragraphs 2-18 and 2-19. For these tests, both SHIP-SHORE and INTERSHIP sections were operating simultaneously. The tuning dial was set for maximum response at 2514 kcs. at the beginning of each test and not changed during the test.

(a) Effect of Humidity on Gain, Noise Level, and Receiver Frequency. The change in receiver gain with variation of humidity was measured in terms of the carrier input voltage required to maintain an arbitrary standard output of 10 mw (signal + noise), with the standard signal generator modulated 80% at 400 cycles per second. Noise outputs with modulation off, and with carrier off, were also measured. Frequency checks were made at each reading with the standard signal generator. Readings were taken at approximately 15 minute intervals.

The results of the test are shown on Plates R-6 to R-9. Tabulations R-7, R-8, and R-9 were derived from these graphs.

(b) Effect of Temperature on Gain, Noise Level, Receiver Frequency and Control Operation. The change in receiver gain with variation of temperature was measured in a way similar to that in the previous test. The signal generator input to the receiver was modulated 80% at 400 cycles per second, and a constant output level of 10 mw. was maintained. Readings were taken at 15 minute intervals. Noise outputs were also checked, as well as signal generator dial readings.

It was noted that large amounts of noise outputs were obtained from the SHIP-SHORE section of the receiver that were not present when the INTERSHIP section alone was operating, or in the output of another receiver under test at the same time.

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The equipment was operated continuously. The controls were checked at -15°C for operation, and were found to be somewhat stiff, but otherwise satisfactory.

Plates R-10 to R-13 show the results of these tests. Tabulations R-10, R-11, and R-12 were derived from these graphs.

The high noise level encountered in the SHIP-SHORE section may have been due to one of the loose connections found in the receiver.

(c) Effect of Humidity on Cold-Start Gain, Noise and Receiver Frequency Characteristics. The input for 10 mw. output, with gain controls on maximum, was measured at 40°C and 23% humidity. Noise was also measured, and signal generator dial readings noted. Input was modulated 80% at 400 cycles per second. The receiver was then turned off and the humidity increased to 97% at the same temperature, as described in paragraph 2-19. The receiver was turned on after two hours and fifteen minutes, and the input for 10 mw. output, noise, and frequency readings immediately measured. The noise output was high for about the first five minutes after applying power to the receiver, and the same noise conditions noted in paragraph 3-7-b existed. The same measurements were then made at suitable short intervals to show the variations occurring after starting up. These readings are shown in graph form on Plates R-6 to R-9.

The values shown in Table R-13 are derived from the above graphs.

3-8. Effects of Vibration and Rolling. The equipment was rolled from side to side for a half-hour, and from front to back for a half-hour. Sensitivity measurements taken during the test do not give usable data due to the high local noise level of variable intensity. During rolling, receiver operation on the SHIP-SHORE "TUNE" position was unstable, due to changes of receiver frequency.

The equipment was vibrated for two minutes, at the end of which time the 6V6 output tube and the 6K8 tube of the INTERSHIP section came out of their sockets. The tubes were replaced and after vibrating an additional two minutes, both tubes came out of their sockets again, the 6K8 taking with it the grid clip, the grid lead being broken at the clip. The lead was resoldered to the grid clip, and the receiver vibrated again. After a few minutes, the jewel indicator lamps failed, due to the excessive movement of the chassis, causing the filaments to break loose. During vibration, the

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dial light flickered due to the poor holder assembly vibrating. The dial was hard to read during vibration, due to the movement of both panel and dial assembly. The left-hand panel retaining screw came loose during vibration. The test was discontinued while it was tightened, and at the end of the test it was almost completely out of its hole. Examination at the end of the test also disclosed the following: the receiver ON-OFF switch was loose; the station selector switch was loose; the nut holding the coil assembly to the can in the INTERSHIP section had come off; the nut on the tuning screw of one of the SHIP-SHORE IF transformers was loose; and the frequency of the "TUNE" position of the SHIP-SHORE section had changed about 200 kcs., due primarily to a rotation of the tuning condenser with vibration.

3-9. Summary of Defects. The following defects were found as a result of the examinations and tests listed in Pars. 3-1 to 3-8.

(a) On "SHIP-SHORE" crystal-controlled oscillator operation, R.F. circuits must be tuned by ear, complicating operation of receiver in the presence of strong local acoustical noise. (Par. 3-1-1)

(b) The use of the bakelite cylinders for mounting components makes replacement of such components and accompanying tube sockets difficult. (Pars. 3-2-aa-j-x-z)

(c) Disassembly is necessary to replace a metal can condenser. (Par. 3-2-j-x)

(d) In several instances, soldering has made removal of of components impossible. (Pars. 3-2-j-u-v)

(e) Ceramic sockets are not used in r.f. circuits. (Pars. 3-2-q-t-)

(f) The paint used for designating tube and crystal sockets shows signs of wearing off. (Par. 3-2-q-t)

(g) One choke in the power supply is not metal-encased. (Par. 3-2-s)

(h) Output transformer on speaker is inadequately protected against moisture. (Par. 3-2-s)

(i) The five-pronged crystal sockets have no identification on them to indicate into which holes the crystal holder should be inserted. (Par. 3-2-t)

(j) The socket for the INTERSHIP position receiver crystal is not marked to designate which crystal should be inserted. (Par. 3-2-t)

(k) The use of electrolytic condensers is undesirable, since experience has proven them to be unreliable. (Par. 3-2-x)

(l) Shortly after being put into operation at the Laboratory, one condenser failed and had to be replaced. (Par. 3-2-x)

(m) The frequency selector switch is of bakelite insulation, instead of ceramic, as is recommended. (Par. 3-2-y)

(n) The use of self-tapping screws in the loudspeaker cabinet and condenser is undesirable. (Par. 3-2-dd)

(o) Soldering and wiring workmanship is poor. (Par. 3-2-u-v-cc)

(p) The radiation voltages appearing at the antenna binding post due to the receiver oscillator are excessive. (Par. 3-6-f)

(q) Low temperatures appear to affect the sensitivity of the equipment adversely. (Plates R-10, R-11, R-12, and Tables R-10, R-11, and R-12)

(r) Temperature and humidity affect to a considerable degree the frequency of the receiver on the SHIP-SHORE "TUNE" position. (Plates R-9 and R-13)

(s) The receiver is apparently not designed to withstand even short periods of vibration. (Par. 3-8)

(t) Tube and crystal sockets are not Naval standard types. (Par. 3-2-q-t)

(u) Tubes used are not Navy approved types. (Par. 3-1-f)

(v) The crystal clamp interferes with removal or replacement of the receiver chassis. (Par. 3-2-t)

(w) An adjustment screw of one of the I-F transformers is mutilated. (Par. 3-2-v)

(x) The INTERSHIP oscillator can be received in the SHIP-SHORE section of the receiver on TUNE as a signal. (Par. 3-6-f)

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Table R-1

Sensitivity, Noise Output, Image Ratio, and I.F. Response of Communications 66B Radio-Telephone Receiver

Gain Control at Maximum; Input Modulated 30% at 400 cps. Output Impedance: 500 ohms

Selector Switch Position	INTER-SHIP	TUNE	SHIP-SHORE 1	SHIP-SHORE 4
Frequency	2738 kcs.	2738 kcs.	2514 kcs.	2670 kcs.
Tuning Knob Position	----	61	48.5	57.4
Input through Standard Dummy Antenna	65.8 µv	22 µv	33 µv	27 µv
A.F. Output in 500 ohms	40 mw	40 mw	40 mw	40 mw
Noise Output - Modulation Off	.9 mw	3 mw	1.1 mw	1 mw
Noise Output - Carrier Off	.04 mw	.4 mw	.1 mw	.08 mw
Image Frequency	3720 kcs.	3668 kcs.	3444 kcs.	3600 kcs.
Image Ratio	420	552	437	483
IF Response from Antenna for 40 mw Output	Over 2v	Over 2v	70,000 µv	300,000 µv

NOTE: I.F. = 491 kcs. for INTERSHIP.
I.F. = 465 kcs. for SHIP-SHORE.

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Table R-2

Selectivity of Communications 66B
Radio-Telephone Receiver

INTERSHIP = 2738 kcs.

Gain Control at Maximum; Input, 30% Modulated
at 400 cps.; Constant Output = 40 mw.

Ratio: Input off max. response / Input at max. response	Ratio in db	Band Width kcs.	Band Width %
1.4	3	5.26	.192
2	6	7.95	.29
10	20	17.	.621
100	40	25.7	.938
1000	60	59.3	2.16
10000	80	74.	2.7

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Table R-3

Selectivity of Communications 66B
Radio-Telephone Receiver

SHIP-SHORE; TUNE = 2738 kcs.

Gain Control at Maximum; Input Modulated 30%
at 400 cps.; Constant Output = 40 mw.

Ratio: Input off max. response / Input at max. response	Ratio in db	Band Width kcs.	Band Width %
1.4	3	4.8	.175
2	6	6.83	.249
10	20	14.1	.514
100	40	28.9	1.056
1000	60	50.7	1.851
10000	80	52.3	1.906

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Table R-4

Selectivity of Communications 66B
Radio-Telephone Receiver

SHIP-SHORE: Position 4 = 2670 kcs.

Gain Control at Maximum; Input Modulated 30%
at 400 cps.; Constant Output = 40 mw.

Ratio: Input off Max. Response / Input at Max. Response	Ratio in db	Band Width kcs.	Band Width %
1.4	3	4.05	.152
2	6	6.22	.233
10	20	13.95	.522
100	40	28.3	1.060
1000	60	51.2	1.915
10000	80	60.1	2.24

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Table R-5

Resonant Overload Characteristics
of Communications 66B Radio-Telephone Receiver;
Gain Control at Max.; "Q" Control
at minimum effect; Input Modulated
30% at 400 cps.

	INTERSHIP 2738 kcs.	SHIP-SHORE Tune	SHIP-SHORE 2670 kcs.
(1) Threshold of AVC action.	Input approx. 60 μv. Output approx. 40 mw.	Input approx. 60 μv. Output approx. 160 mw.	Input approx. 60 μv. Output approx. 150 mw.
(2) Input for 6 db change in AVC threshold output.	140 μv.	240 μv.	180 μv.
(3) Range of linear detection below AVC threshold.	Input 33 to 60 μv. Output 14 to 40 mw.	Input 15 to 60 μv. Output 17 to 160 mw.	Input 20 to 60 μv. Output 23 to 150 mw.
(4) Carrier Noise Output. (Modulation off)	---	Max. 2.4 mw. Min. .029 mw. Ratio 19.2 db.	Max. 1.4 mw. Min. .02 mw. Ratio 18.5 db.
(5) Range of Input Variation to decrease Carrier noise from max. to min. value.	60 to 10,000 μv. (44.5 db)	20 to 7,000 μv. (51 db)	60 to 10,000 μv. (44.5 db)
(6) Max. power output of receiver.	1490 mw.	1410 mw.	1480 mw.

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Table R-6

Radiation Voltage Due to Receiver Oscillator
Appearing at Antenna Terminals of Communications
66B Radio-Telephone Receiver

Gain control at max.

Frequency Switch Position	SHIP-SHORE 1	SHIP-SHORE 4	SHIP-SHORE TUNE	INTER-SHIP
Receiver Osc. Freq.	2979 kcs.	3135 kcs.	3203 kcs.	3229 kcs.
Tuning Knob Position	47.9	56.7	61	
Radiation Voltage - Fundamental	10900 µv	8500 µv	External Interference	
Radiation Voltage - Second Harmonic	1060 µv	495 µv	105 µv	70 µv
Radiation Voltage - Third Harmonic	400 µv	345 µv	350 µv	72 µv
Radiation Voltage - Fourth Harmonic	1250 µv	1900 µv	530 µv	800 µv
Radiation Voltage - Fifth Harmonic	1100 µv	700 µv	70 µv	98 µv

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Table R-7

Effect of Humidity on Gain and Noise Level of Communications 66B Radio-Telephone Equipment

INTERSHIP - f = 2738 kcs.

Gain Control at Maximum

Humidity	27% (start)	95%	20% (return)
Time	0	75 min.	195 min.
Input for 10 mw Output	1025 µv	940 µv	980 µv
Gain Ratio	1.0	1.09	1.05
DB Change in Initial Gain	0	+.75 db	+.45 db
Noise Level	No definite conclusions, due to high local noise level.		

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Table R-8

Effect of Humidity on Gain and Noise Level of Communications 66B Radio-Telephone Equipment

TUNE - f = 2514 kcs.

Gain Control at Maximum

Humidity	27% (start)	95%	20% (return)
Time	0	75 mins.	195 mins.
Input for 10 mw Output	550 μv	610 μv	600 μv
Gain Ratio	1.0	.9	.92
DB Change in Initial Gain	0	-.9 db	-.7 db
Noise Level	No definite conclusions, due to high local noise level.		

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Table R-9

Effect of Humidity on Gain and Noise Level of Communications 66B Radio-Telephone Equipment

SHIP-SHORE = 2514 kcs.

Gain Control at Maximum

Humidity	27% (start)	95%	20% (return)
Time	0	75 mins.	195 mins.
Input for 10 mw Output	600 µv	665 µv	630 µv
Gain Ratio	1.0	.9	.95
DB Change in Initial Gain	0	-.9 db	-.45 db
Noise Level	No definite conclusions, due to high local noise level.		

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Table R-10

Effect of Temperature on Gain and Noise Level of Communications 66B Radio-Telephone Equipment

INTERSHIP - f = 2738 kcs.

Gain Control set at Max.

Temperature	50° C. (start)	50° C. (end)	(Approx.) -15° C. (start)	(Approx.) -15° C. (end)
Time	0	90 min.	195 min.	330 min.
Input for 10 mw Output	1080 µv	770 µv	5900 µv	6900 µv
Gain Ratio	1	1.4	.183	.157
DB Change in Initial Gain	0	+2.9 db	-14.75 db	-16.1 db
Carrier Noise Level - Mod. off	1.6 mw	2.3 mw	.6 mw	.12 mw
Carrier Noise Ratio	1	1.44	.375	.075
DB Change in Carrier Noise	0	+1.6 db	-4.25 db	-11.3 db
Noise Output - Carrier Off	.95 mw	.8 mw	.5 mw	.04 mw
Noise Ratio - Carrier Off	1	.84	.527	.042
DB Change in Noise Output - Carrier Off	0	-.75 db	-2.8 db	-13.8 db

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Table R-11

Effect of Temperature on Gain and Noise Level of Communications 66B Radio-Telephone Equipment

SHIP-SHORE - "TUNE" - f = Approx. 2514 kcs.

Gain Control set at Max.

Temperature	50° C. (start)	50° C. (end)	(Approx.) -15° C. (start)	(Approx.) -15° C. (End)
Time	0	90 min.	195 min.	330 min.
Input for 10 mw Output	570 µv	750 µv	2000 µv	2000 µv
Gain Ratio	1	.76	.285	.285
DB Change in Initial Gain	0	-2.4 db	-10.9 db	-10.9 db
Carrier Noise Level - Mod. off	.75 mw	1.8 mw	2.0 mw	.15 mw
Carrier Noise Ratio	1	2.4	2.76	.2
DB Change in Carrier Noise	0	+3.8 db	+8.8 db	-7.0 db
Noise Output - Carrier Off	.15 mw	.7 mw	1.4 mw	.03 mw
Noise Ratio - Carrier Off	1	4.65	9.35	.2
DB Change in Noise Output - Carrier Off	0	+6.68 db	+9.7 db	-7.0 db

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Table R-12

Effect of Temperature on Gain and Noise Level of Communications 66B Radio-Telephone Equipment

SHIP-SHORE - Pos. 1 - f = 2514 kcs.

Gain Control set at Max.

Temperature	50° C. (start)	50° C. (end)	(Approx.) -15° C. (start)	(Approx.) -15° C. (end)
Time	0	90 min.	195 min.	330 min.
Input for 10 mw Output	560 µv	900 µv	1900 µv	2000 µv
Gain Ratio	1	.622	.294	.28
DB Change in Initial Gain	0	-4.1 db	-10.6 db	-11.1 db
Carrier Noise Level - Mod. Off	.7 mw	.7 mw	2.0 mw	.12 mw
Carrier Noise Ratio	1	1	2.86	.172
DB Change in Carrier Noise	0	0	+4.55 db	-7.65 db
Noise Output - Carrier Off	.1 mw	.2 mw	1.3 mw	.03 mw
Noise Ratio - Carrier Off	1	2	1.3	.3
DB Change in Noise Output - Carrier Off	0	+3 db	+11.3 db	-5.23 db

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Table R-13

Effect of Humidity on Cold-Start, Gain, and Noise Characteristics of Communications 66B Radio-Telephone Receiver.

INTERSHIP - f = 2738 kcs.

Gain Control on Max. - Equipment turned off from 0 to 135 min.

Condition	Initial Check (a)	Equipment turned on (b)	Reading (c)	Reading (d)	Final Reading (e)
Time	0	135 min.	140 min.	150 min.	195 min.
Humidity	23%	97%	97%	97%	59%
Input for 10 mw Output	990 μv	2000 μv	1300 μv	1300 μv	860 μv
Gain Ratio	1	.495	.76	.76	1.15
DB Change in Gain	0	-6.1 db	-2.4 db	-2.4 db	+1.2 db
Carrier Noise Level - Mod. Off	.85 mw	4.0 mw	3.5 mw	3.0 mw	1.3 mw
Carrier Noise Ratio	1	4.7	4.12	3.53	1.53
DB Change in Carrier Noise	0	+6.7 db	+6.15 db	+5.48 db	+1.85 db
Noise Output - Carrier Off	.11 mw	8 mw	2.0 mw	1.5 mw	.35 mw
Noise Ratio - Carrier Off	1	72.5	18.2	13.6	3.18
DB Change in Noise - Carrier Off	0	+18.5 db	+12.5 db	+11.5 db	+5.0 db

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Table TR-1
DIMENSIONS AND WEIGHTS
Communications Co. 50-A, 66B, 12-volt d-c Equipment

Transmitter Unit:		Weight: 21-1/4 lbs.
Length:	10-3/4 in.	
Height:	10-3/4 in.	
Depth:	11-3/8 in.	
Receiver Unit:		Weight: 19-1/2 lbs.
Length:	10-3/4 in.	
Height:	10-3/4 in.	
Depth:	10-7/8 in.	
Modulator - Power Supply Unit:		Weight: 41 lbs.
Length:	12 in.	
Height:	10-1/2 in.	
Depth:	13-1/4 in.	
Speaker:		Weight: 7-1/4 lbs.
Length:	9 in.	
Height:	10-3/8 in.	
Depth:	6-1/4 in.	
Microphone:		Weight: 3/4 lb.
Cables:		
Modulator to Transmitter:		Lth: 12-1/2 ft. Wt: 3-1/4 lbs.
Power Supply to Batteries:		Lth: 5 ft. Wt: 3/4 lb.
Power Supply to Receiver:		Lth: 10-1/2 ft. Wt: 2 lbs.
Receiver to Loudspeaker:		Lth: 4 ft. Wt: Included in speaker.
Microphone Cord:	Lth: 5 ft.	Wt: Included in microphone.
Fishpole Antenna:		Weight: 10-1/2 lbs.

Total Weight (including antenna) = 106-1/4 lbs.

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Table TR-2
NAMEPLATE DATA
Communications Co. 50-A, 66B, 12-volt d-c Equipment

Modulator - Power Unit.

1. Size: 2-5/8" x 7/8" (on chassis)
"Manufactured by Communications Co., Inc.
Coral Gables, Florida
Model 56B Serial 197"

2. Size: 2-9/16" x 1-9/16" (on dynamotor)
"Eicor Inc., Chicago, Ill.
Dynamotor, No. 8831; Type 4125; P.S. 12
Temp. Rise 50° C.; RPM 5000; Duty, Int.
Input Volts 12; Output Volts 600
Input Amps. 15; Output Amps. .200"

3. Size: 2-1/4" x 3/8" (on receiver dynamotor)
"Pioneer Gen-E-Motor Corp.
Made in Chicago, Ill., U.S.A.
Model H No. P-1759"

4. Size: 2-3/4" x 1-1/4" (paper label inside receiver dynamotor case)
"Warranty: Pincor Gen-E-Motors are guaranteed against defective materials and workmanship for ninety (90) days after delivery to original purchaser. Defects will be repaired if the unit has not been tampered with and is returned transportation prepaid. Apply Pioneer Grease No. 1880 approximately every 750 hours of service. Do not pack grease tightly in bearings. Code No. JW H 265 Input volts 12 Output 265 volts .075 amperes."

Receiver Unit.

5. Size: 2-5/8" x 7/8" (on panel)
"Manufactured by Communications Co., Inc.
Coral Gables, Florida
Model 66B Serial 197"

Transmitter Unit.

6. Size: 2-5/8" x 7/8" (on panel)
"Manufactured by Communications Co., Inc.
Coral Gables, Florida
Model 50A Serial 188"

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Table TR-2 (continued)

Antenna Unit.

7. Size: 2-5/8" x 7/8"
"Manufactured by Communications Co., Inc.
Coral Gables, Florida
Model 2738 Serial 110"

Microphone.

8. Universal Handi-Mike
Model 200TC Type: Carbon

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Table T-1
DETERMINATION OF POWER OUTPUT
Communications Co. 50-A, 12 volts d-c, Serial No. 188

Selector Switch Position:	1	2	3	4
Frequency:	2118	2142	2738	2670
I_{PA} Cathode, ma.	150	162	145	155
I_{PA} Grid, ma.	4	4.8	4	5
$I_{Mod.}$ Cathode, ma.	78	80	80	80
E_{Line}, volts	12	12.3	12.3	12.3
Watts Output	38 Note 1	39.4 Note 2	36.6 Note 3	32 Note 4

Note 1. From the maximum output of 38 watts, the output diminished after a period of approximately 3 minutes of key-down operation to only 29.8 watts. At this time the P.A. tank coil was noticeably hot to the touch.

2. Minimum 29.8 watts after approximately 3 minutes of key-down operation.

3. Minimum 29.8 watts after 3 minutes of key-down operation.

4. Minimum 28.6 watts after 3 minutes of key-down operation.

Antenna: 50-watt, 32-volt lamp +300 μμf.

Measurements were made after tuning up to maximum output on each frequency. Simultaneous adjustment on all bands was not accomplished in the measurements shown above.

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Table T-2
DETERMINATION OF POWER OUTPUT
Communications Co. 50-A, 12 volts d-c, Serial No. 188

Selector Switch Position:	1	2	3	4
Frequency:	2118	2142	2738	2670
I_{PA} Cathode, ma.	170	150	165	135
I_{PA} Grid, ma.	4	4.7	3.8	5.4
$I_{Mod.}$ Cathode, ma.	75	75	75	78
E_{Line}, volts	12.1	12.1	12.0	12.0
Watts Output	35	36.3	32.6	27.4

Antenna: 50-watt, 32-volt lamp + 300 μμf.

Compromise tuning adjustments made for Channels 1 and 2, 3 and 4.

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Table T-3
DETERMINATION OF POWER OUTPUT
Communications Co. 50-A, 12 volts d-c, Serial No. 188

Selector Switch Position:	1	2	3	4
	(No Modulation)			
Frequency:	2118	2142	2738	2670
I_{PA} Cathode, ma.	137	148	142	153
I_{PA} Grid, ma.	3.8	4.5	3.8	4.8
$I_{Mod.}$ Cathode, ma.	82	82	83	82
I_{RF} External Amps.	0.72	0.73	0.73	0.72
E_{Line} Volts	12.1	12.2	12.3	12.1
Watts Output	36.8	36.6	37.2	36.2
	(With Whistle Modulation)			
I_{PA} Cathode, ma.	135	143	135	148
I_{PA} Grid, ma.	3.6	4.2	3.7	4.6
$I_{Mod.}$ Cathode, ma.	142	143	142	146
I_{RF} External Amps.	0.83	0.80	0.83	0.81
E_{Line} Volts	12.1	12.2	12.2	12.1
Watts Output	51.0	51.2	50.8	52.3

Note 1. Measurements were made after tuning up to maximum output on each frequency.

2. Antenna: 50-watt, 64-volt lamp + 300 μμf

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Table T-4
DETERMINATION OF POWER OUTPUT
Communications Co. 50-A, 12-volt d-c, Serial No. 188

(No Modulation)

Selector Switch Position:	1	2	3	4
Frequency:	2118	2142	2738	2670
I_{PA} Cathode, ma.	137	140	150	155
I_{PA} Grid, ma.	3.9	4.4	3.7	4.7
$I_{MOD.}$ Cathode, ma.	83	82	81	82
I_{RF} External amps.	0.87	0.86	0.87	0.84
E_{Line} volts	12.1	12.0	12.2	12.08
Watts Output	38.2	37.3	38.2	35.6

(With Whistle Modulation)

I_{PA} Cathode, ma.	133	140	142	152
I_{PA} Grid, ma.	3.7	4.2	3.6	4.5
$I_{Mod.}$ Cathode, ma.	140	143	143	147
I_{RF} External amps.	1.06	1.04	1.00	1.02
E_{Line} volts	12.1	11.93	12.1	12.0
Watts Output	56.7	54.6	50.5	52.6

Note 1. Measurements were made after tuning up to maximum output on each frequency.

2. Antenna: 50.5 ohms (plaque resistors) +300 μμf.

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Table T-5
OPERATION WITH AN ACTUAL ANTENNA
Communications Co. 50-A, 12 volts d-c, Serial No. 188

Antenna - Communications Co. fish-pole antenna Model 2738, Serial 110. Lead from antenna to set 29 ft. total.

Condition - Tuned for maximum output on each frequency.

Line Voltage during test - 12.15 volts.

Frequency	Channel	I_{PA} ma.	I_{RF} Ext. Amp.	R.F. Watts Output
2118	1	157	1.66	33.1
2142	2	160	1.61	32.4
2738	3	154	1.29	54.1
2670	4	150	1.32	50.5

Condition - Initially tuned to best compromise for Channels 1 and 2, 3 and 4.

Line Voltage during test - 12 volts.

Frequency	Channel	I_{PA} ma.	I_{RF} Ext. Amp.	R.F. Watts Output
2118	1	170	1.50	27.0
2142	2	140	1.50	28.1
2738	3	158	1.11	40.0
2670	4	137	1.13	37.1

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Table T-6
INCLINATION TEST
Communications Co. Model 50-A, 12 volts d-c, Serial No. 188

Inclination: Side to Side

Time	I_{PA}	I_{Grid}	$I_{Mod.}$	Line Volts	I_{RF} External	Watts Output	Condition
1524	160	3.9	80	11.9	1.27	16.1	Stationary
25	159	3.8	80	12.0	1.27	16.1	Inclination
30	163	4.2	80	12.0	1.32	17.4	"
35	160	4.1	79	11.9	1.31	17.2	"
40	153	3.5	80	12.0	1.25	15.6	"
45	165	3.9	82	12.3	1.36	18.5	"
50	160	3.8	80	11.9	1.31	17.2	"
55	159	3.4	82	12.2	1.29	16.7	"
56	150	3.3	80	12.0	1.28	16.4	Stationary

Inclination: Front to Back

854	152	3.0	78	11.8	1.14	13.0	Stationary
855	151	2.8	80	11.9	1.30	16.9	Inclination
900	160	3.9	82	12.1	1.33	17.7	"
05	162	3.8	80	12.0	1.33	17.7	"
10	160	3.6	80	11.9	1.30	16.9	"
15	154	3.2	80	12.1	1.27	16.1	"
20	162	3.4	83	12.3	1.31	17.2	"
25	155	3.3	80	11.8	1.25	15.6	"
26	148	3.2	78	11.8	1.28	16.4	Stationary

Notes (1) Antenna: 10-ohm plaque resistor + 300 μμf.

(2) The equipment was operated on Channel 3, 2738 kcs. during the test.

(3) Quality of modulation was observed on another radio-telephone receiver at frequent intervals.

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Table T-7
VARIATION IN AMBIENT TEMPERATURE
Communications Co. 50-A, 12 volts d-c, Serial No. 188

Time	Temp. °C.	Rel. Hum.	Line Voltage	I PA Cathode	I PA Grid	I Mod. Cathode	I_{RF} External Amps.	Output Watts
8.35	50	30	11.9	140	3.9	75	1.52	23.1
8.50	50	35.5	11.8	143	3.7	73	1.40	19.6
9.05	49.5	24.5	11.9	148	4.1	74	1.45	21.0
9.20	49	24.5	11.9	149	4.1	73	1.45	21.0
9.35	50	18	11.9	150	3.3	73	1.45	21.0
9.50	50	18	12	148	3.9	73	1.4	19.6
10.05	50	18	12	148	3.3	73	1.45	21.0
10.20	33.5	21						
10.35	14	37						
10.50	2.5							
11.10	-5.							
11.20	-8.							
11.35	-11.							
11.50	-13.							
12.00	-15.							
12.15	-15.5							
12.30	-13.5							
12.45	-15.							
13.00	-15.5							
13.15	-15.2							
13.30	-15.		11.0	113	5.1	78	1.45	21.0
13.55	-15.5		11.4	113	5.3	80	1.46	21.3
14.10	-15.							
14.20	-15.5		11.5	115	5.3	80	1.48	21.9
14.35	-15.		11.6	115	5.3	80	1.46	21.3
14.50	-15.		11.6	116	5.3	80	1.47	21.6

Notes: (1) Frequency used during test - 2670 kcs.

(2) Output signal checked at frequent intervals by means of a radio-telephone receiver located outside the temperature chamber.

(3) During the first and last periods of the test, the receiver operated continuously while the transmitter was on only long enough to take readings. The entire equipment was shut down at 10.05 and remained idle until 13.30.

[redacted]

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Table T-8
VARIATION OF HUMIDITY
Communications Co. 50-A, 12 volts d-c, Serial No. 188

Time	Temp. °C.	Rel. Hum.	Line Voltage	I_{PA} Cathode	I_{PA} Grid	$I_{Mod.}$ Cathode	I_{RF} External Amps.	Output Watts
8.15	21.5	42.5	12.2	133	4.0	80	1.58	25
8.45	41	26	11.5	133	4.2	77	1.51	22.8
9.05	40	27	11.6	137	3.9	73	1.47	21.6
9.20	40	27	12.0	138	3.0	73	1.46	21.3
9.40	39.5	43.5	11.8	143	4.0	73	1.46	21.3
9.50	40	91	12.4	144	4.0	70	1.36	18.5
10.05	40	94	11.7	143	4.1	72	1.41	19.9
10.20	40	97	11.8	143	4.1	73	1.46	21.3
10.35	40	94	11.5	140	4.0	73	1.46	21.3
10.50	40	97	11.5	140	3.9	73	1.46	21.3
11.05	39.5	71	11.4	140	4.0	73	1.44	20.7
11.20	39.5	52	11.5	140	3.9	73	1.46	21.3
11.35	39.5	43.2	11.6	140	3.8	73	1.46	21.3
11.50	40	38	11.7	140	3.8	73	1.45	21.0
12.05	40	25	11.6	138	3.9	73	1.45	21.0
12.20	38.9	22	11.6	140	3.9	73	1.45	21.0
12.35	40	19	11.3	140	3.8	73	1.45	21.0
12.50	39.5	20.5	11.5	140	4.0	73	1.43	20.4
13.05	40	25	11.7	140	3.9	73	1.43	20.4
13.20	40.5	91						
13.35	40.5	91						
13.50	40.5	94						
14.05	40.5	94						
14.20	40	97						
14.35	40	94						
14.50	40	97						
15.05	40	97						
15.15	40	97						
15.35	40	97	11.2	122	2.5	73	1.37	18.8
15.50	40.5	97	11.4	138	3.5	72	1.35	18.2
16.05	39.5	71	11.5	140	3.7	72	1.40	19.6
16.15	36	59	11.4	140	3.9	72	1.37	18.8

Notes: (1) Frequency used during test - 2670 kcs.

(2) Output signal checked at frequent intervals by means of a radio-telephone receiver located outside the temperature chamber.

(Continued)

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Table T-8 (cont'd)

(3) During the test the receiver operated continuously while the transmitter was on only long enough to take readings. The entire equipment was shut down at 13.05. The receiver was restarted at 15.15 while the transmitter was placed in operation at 15.35.

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Table T-9
LOCKED KEY OPERATION FOR ONE HOUR
Communications Co. Model 50-A 12 volts d-c Serial No. 188

Time	I_{PA}	I_{Grid}	$I_{Mod.}$	Line Volts	I_{RF} External	Watts Output	Dynamotor Temp. °C.	Dynamotor Output Volts
Filaments on at 13.03								
13.10	153	3.0	87	12.7	0.95	45.1	19	580
15	133	3.4	83	12.1	0.83	34.5	22	552
20	130	3.7	83	12.1	0.80	32.0	26	550
25	127	3.8	82	12.1	0.78	30.4	31.5	547
30	124	3.7	82	12.1	0.77	29.6	36.5	542
35	123	3.2	81	12.02	0.77	29.6	42.5	540
40	123	3.1	81	12.0	0.76	28.9	47.5	535
45	122	2.7	80	12.0	0.76	28.9	50.5	532
50	122	2.8	80	11.93	0.76	28.9	54.0	530
55	120	2.9	78	11.9	0.75	28.1	57.0	525
14.00	120	2.9	78	11.9	0.74	27.4	59.5	524
05	120	2.8	78	11.9	0.74	27.4	62.0	520
10	119	3.0	77	11.9	0.74	27.4	64.5	515

Note: 1. Ambient Temperature = 19.5° C.

2. Test performed on Channel 3, 2738 kcs. without modulation.

3. Antenna: 50 ohms (plaque resistors) + 300 µµf.

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Table T-10

MEASUREMENT OF PERCENTAGE OF MODULATION AND HARMONIC DISTORTION

Communications Co. Model 50A, 12 volts d-c, Serial No. 188

Per Cent Modulation Positive	Per Cent Modulation Negative	Per Cent Distortion	Carrier
18	20	2.2	100
26	30	2.1	100
36	40	1.9	100
46	50	1.4	99
54	60	3.1	98
61	70	8.5	98
69	80	11.1	97
77	90	11.1	97
87	100	11.1	96

Note (1) Distortion measured at 400 cycles with the Radio Research Co. Model OB Audio Analyzer Equipment.

(2) Test performed on Channel 2, 2142 kcs.

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Table T-11
AUDIO FREQUENCY CHARACTERISTIC
FROM MICROPHONE TRANSFORMER TO CARRIER
Communications Co. 50-A, 12 volts d-c, Serial No. 188

Modulation Frequency Cycles	Per Cent Modulation Neg. Peaks	Modulation Level Relative to 83% Modulation Db
4500	85	+.2
4000	85	+.2
3000	84	+.1
2500	83	0
2000	83	0
1500	83	0
1200	82	-.12
1000	83	0
800	83	0
600	82	-.12
500	82	-.12
400	82	-.12
300	81	-.22
200	78	-.54
150	75	-.88
100	65	-2.12

Notes: (1) Test performed at 2142 kcs.

(2) The above data were taken with the Radio Research Co. Model OB Audio Analyzer.

(3) During the test, a 350-ohm non-inductive resistor was substituted for the microphone. The audio voltage applied to the input circuit was held constant at 0.22 volts.

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Table T-12
POWER REQUIRED FROM SUPPLY LINES
Communications Co. Model 50-A, 12 volts d-c, Serial No. 188

Condition	Line Volts	Line Amps.	Input Watts
Stand-by - Receiver Only	12.5	8.1	98.4
Transmitter Only - Key up	12.3	2.28	28.0
Transmitter & Receiver - Key down, Full Output.	12.0	25.7	308.0
Receiver on, Transmitter starting: input.	11.7	43.0	503.0

Note: Test conducted on Channel 2, 2142 kcs.

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Table T-13
ANTENNA SHORT-CIRCUITED AND OPEN-CIRCUITED
Communications Co. Model 50-A, 12 volts d-c, Serial No. 188

Channel:	1	2	3	4
Frequency:	2118	2142	2738	2670
Normal Operation				
I_{PA}, ma.	120	146	162	168
I_{RF}, Ext., amp.	1.53	1.6	1.2	1.3
Antenna Shorted				
I_{PA}, ma.	180	182	75	128
I_{RF}, Ext., amp.	0	0	0	0
Antenna Open				
I_{PA}, ma.	184	188	134	50
I_{RF}, Ext., amp.	0	0	0	0

Antenna: 10-ohm, non-inductive resistor +300 μμf.

Condition: Initially tuned with compromise adjustment to permit approximately equal output on all bands.

Line Voltage during test was 12.1 to 12.2 volts.

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Table T-14
VACUUM TUBE OPERATING CONDITIONS
Communications Co. 50-A, 12 volts d-c, Serial No. 188

	Type	E_p	E_{SG}	E_G	E_H
P.A.	807	515	270	-130	5.85 & 6.08
Oscillator	6V6	170	135	-27	5.7
Modulators	807	546	294	-24	6.13 & 6.10
Speech Amplifiers	6C5	294	-	-9.35	6.1

Notes: (1) Line Voltage varied from 12.65 to 12.8 during test.

(2) Antenna: 10-ohm non-inductive resistor +300 μμf.

(3) Condition: Tuned up on Channel 2, 2142 kcs.

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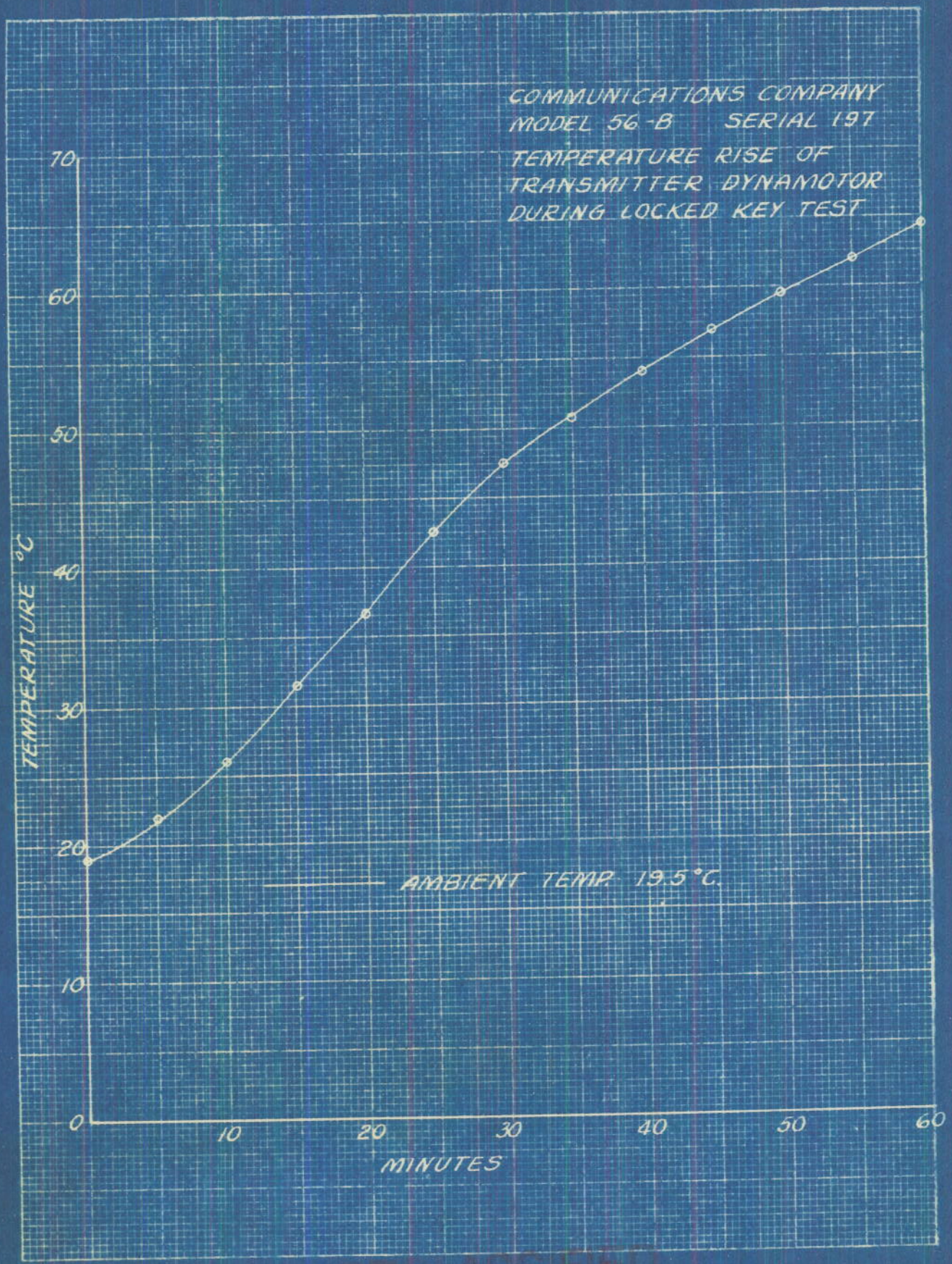
Table T-15
FUSES
Communications Co. 50-A, 12 volts d-c, Serial No. 188

Circuit Position	Mfgr.	Rating	Actual Full Load	Overall Length	Ferrule Diam.	Type
Receiver Filaments & Genemotor	Buss	10-a.	5.15-a.	1-15/32	13/32	Glass Body
Transmitter Filaments and Relays	Buss	10-a.	4.0	1-15/32	3/8	Glass Body
Dynamotor Input	Littelfuse	50-a., 25-v.	19.6-a.	1-7/16	13/32	Glass Body, anti-vibration
Dynamotor Output	Littelfuse	1/2-a., 1000-v.	290 ma., 565-v.	2-15/16	3/8	Fiber Body; non-renewable

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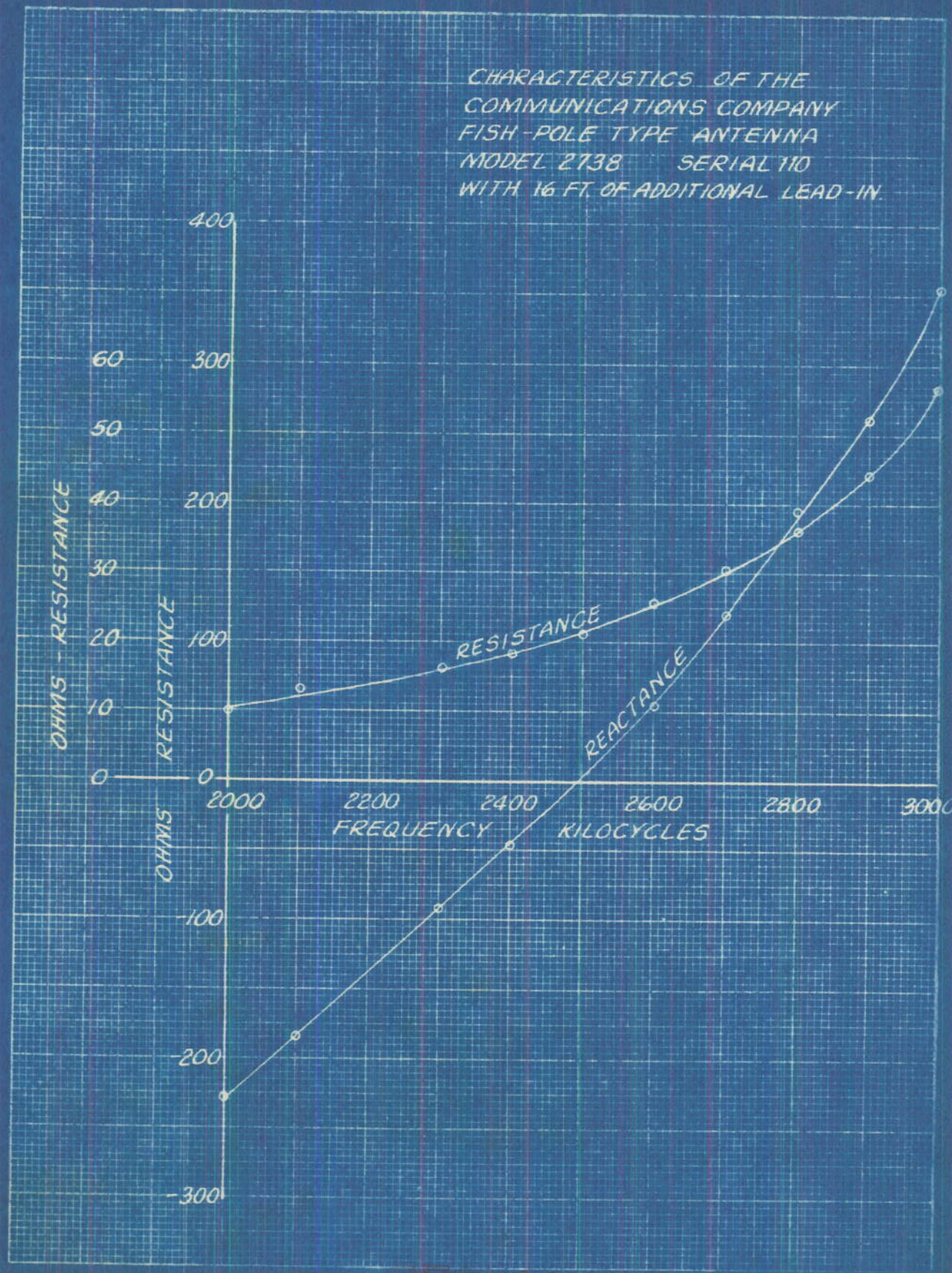
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DATE



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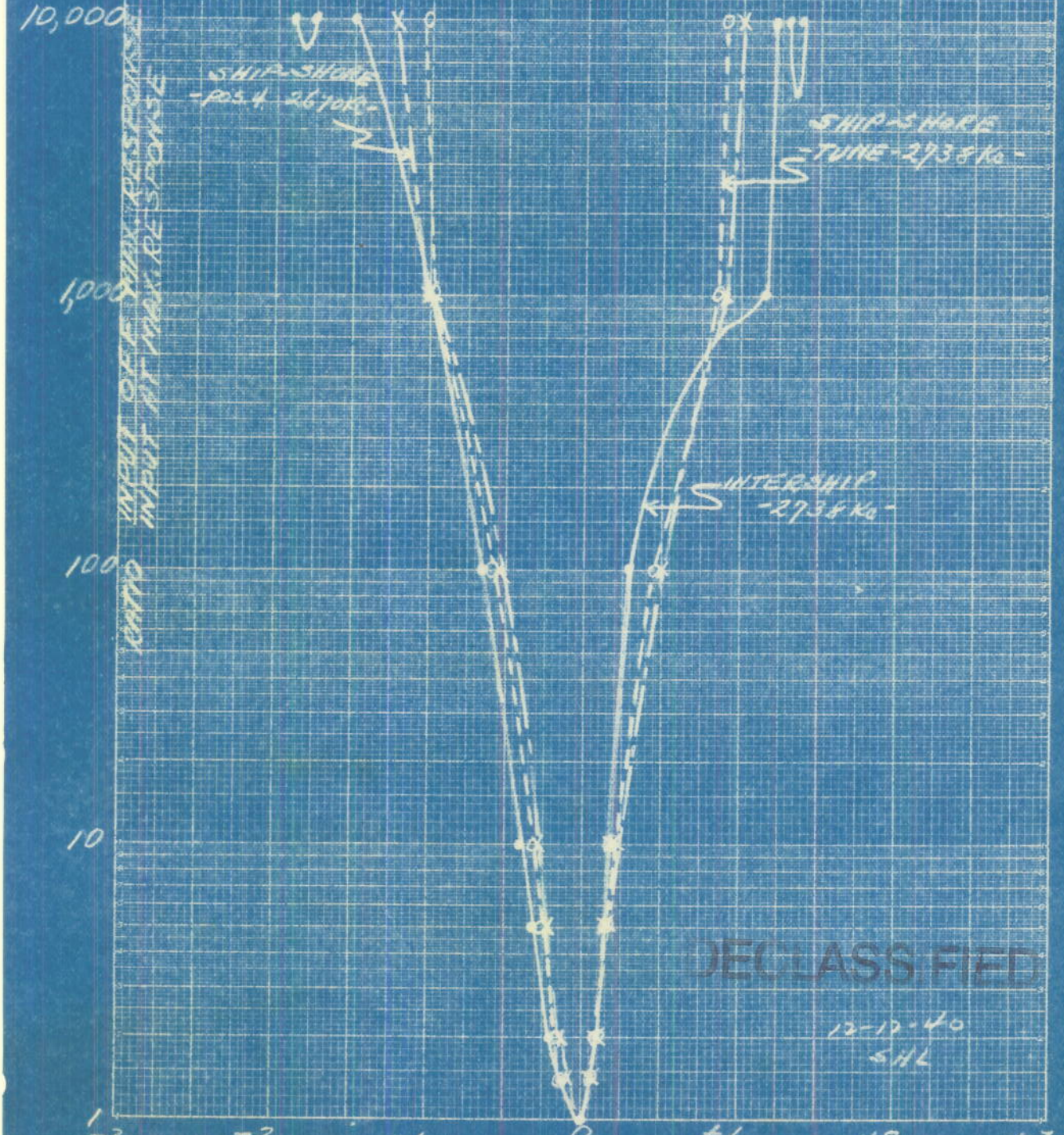
PLATE T-1



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PLATE T-2

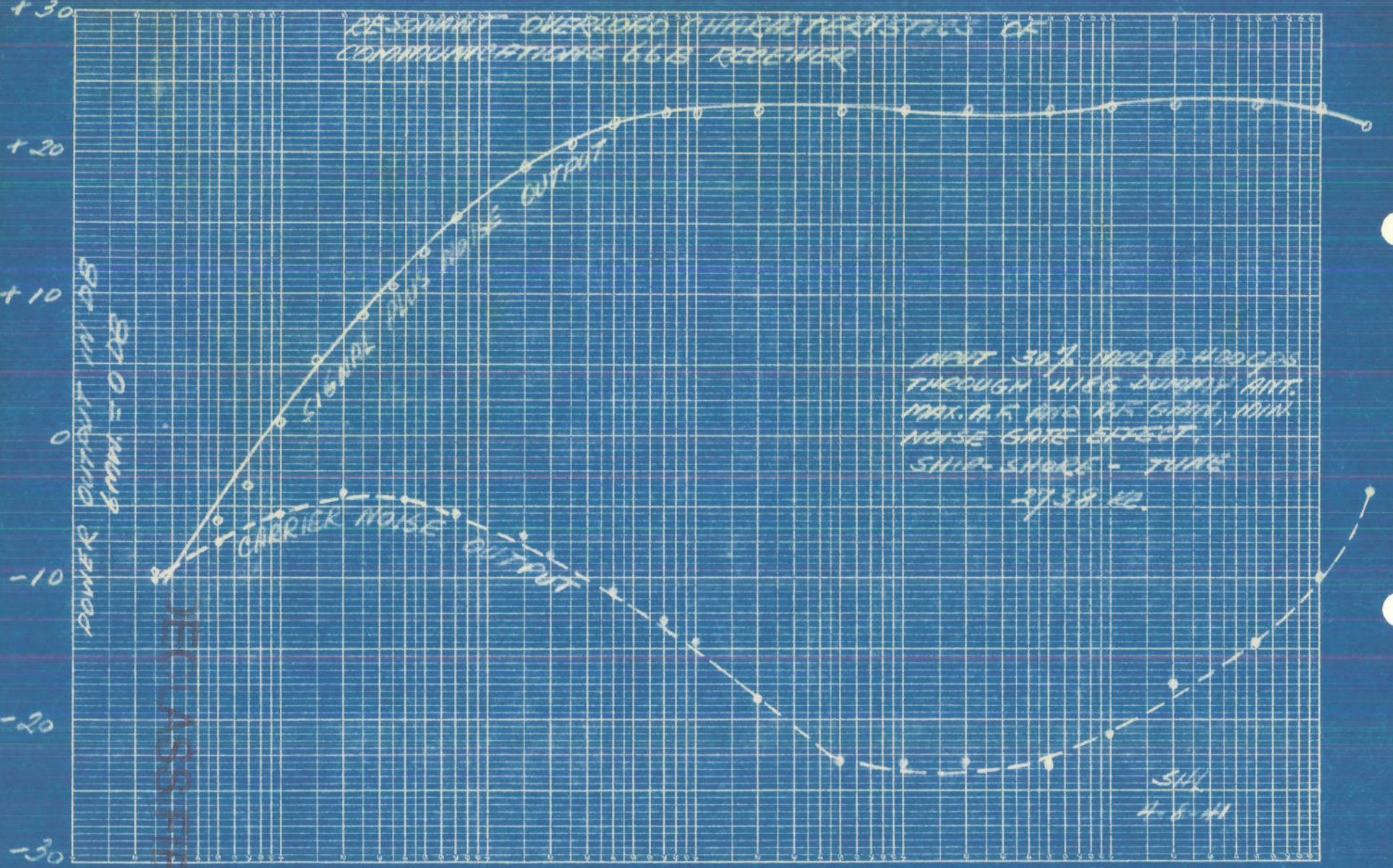
SELECTIVITY CHARACTERISTIC OF COMMUNICATIONS 668 RECVR.
INPUT MOD. 30% AT 400 CPS THROUGH DUMMY ANTENNA 41.8 DB GAIN AT MAX., NOISE GATE CONTROL AT MIN. EFFECT. B.W. = 4.6 KC. FOR SHIP-SHORE AND 4.9 KC. FOR INTERSHIP



DECLASSIFIED
12-10-40
SHL

PLATE R-1

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+30
+20
+10
0
-10
-20
-30
1
10
100
1,000
10,000
100,000
1 MEGT
POWER OUTPUT IN DB BELOW 1 MW
CARRIER INPUT - MICROVOLTS
CARRIER NOISE OUTPUT
SIGNAL PLUS NOISE OUTPUT
INPUT 30% MOD @ 400 CPS THROUGH LINKS SUMMIT ANT. MAX. A.F. AND R.F. GAIN, MIN. NOISE GATE EFFECT, SHOP-SHACK - TUNE -3738 KC.
SUM 4-8-41
PLATE R-3

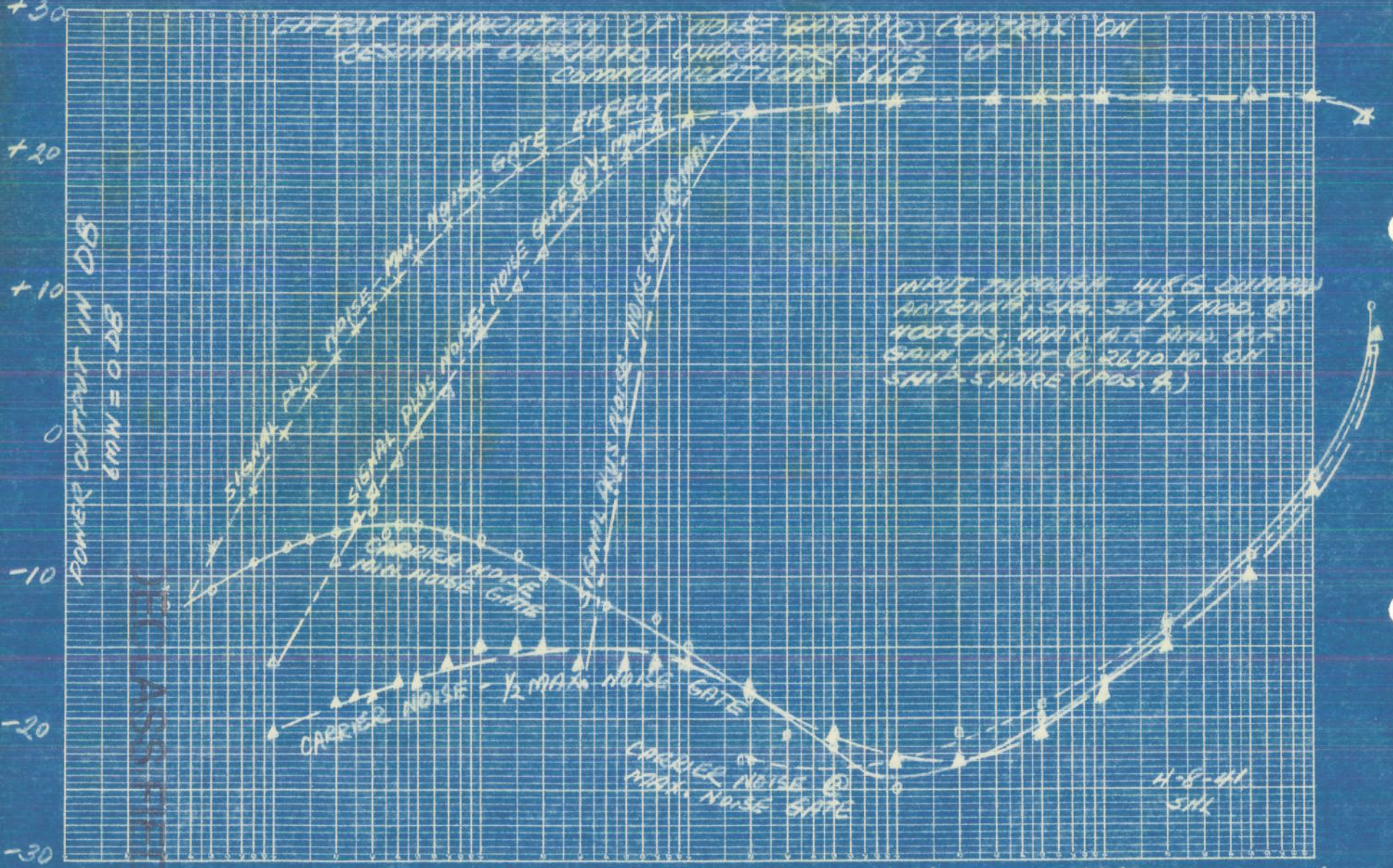
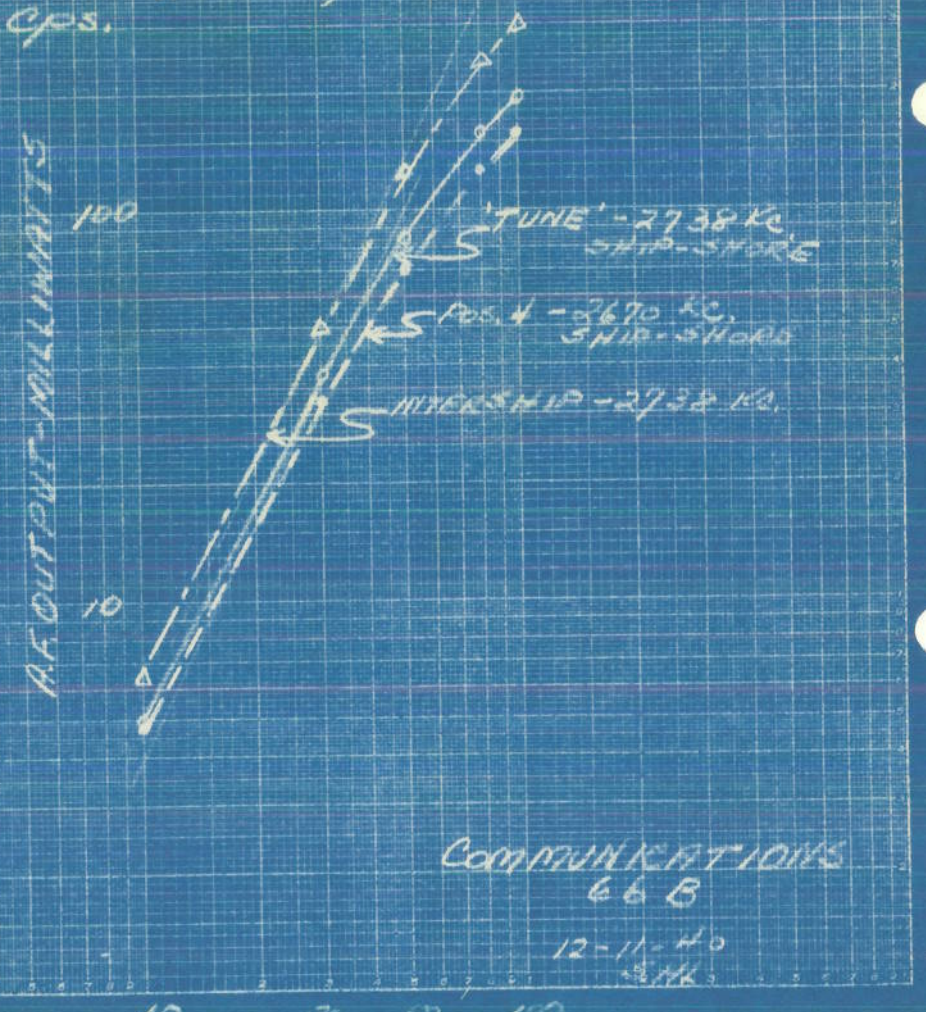

+30
+20
+10
0
-10
-20
-30
POWER OUTPUT IN DB
0 DB = 1 MW
1
10
100
1,000
10,000
100,000
1 VOLT
CARRIER INPUT - MICROVOLTS
CONSTANT CARRIER AND NOISE GATE (R) CONTROL ON
SIGNAL PLUS NOISE GATE
SIGNAL PLUS NOISE GATE
SIGNAL PLUS NOISE GATE
CARRIER NOISE - ½ MAX. NOISE GATE
CARRIER NOISE GATE
CARRIER NOISE @ MAX. NOISE GATE
INPUT IMPEDANCE 41 Ω UNBALANCED
ANTENNA, USE 300 Ω TWIN LEAD
FOR 75 Ω USE 4:1 BALUN TO
CONN. INPUT @ 2670 KC. OR
SMALLER (RES. 8)
41 Ω UNBALANCED SMC

PLATE R-4

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EFFECT OF MODULATION DEPTH ON A.F. OUTPUT - MAX. A.F. AND R.F. GAIN; MIN. NOISE GATE EFFECT, ANT. INPUT ON LINEAR PORTION OF RESONANT OVERLOAD CHARACTERISTICS, MOD. FREQ. = 400 C.P.S.

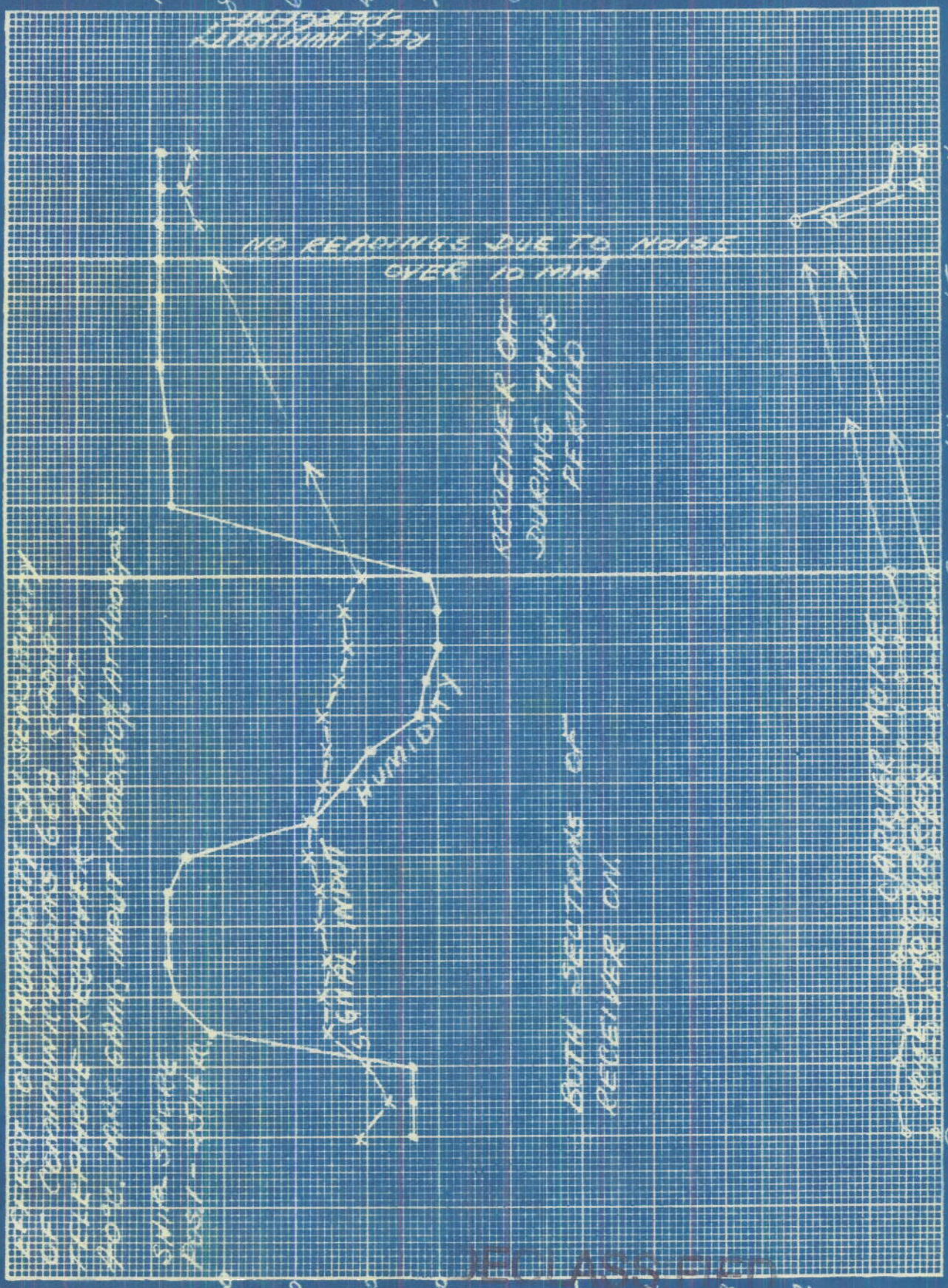


COMMUNICATIONS
66 B
12-11-40

PLATE R-5

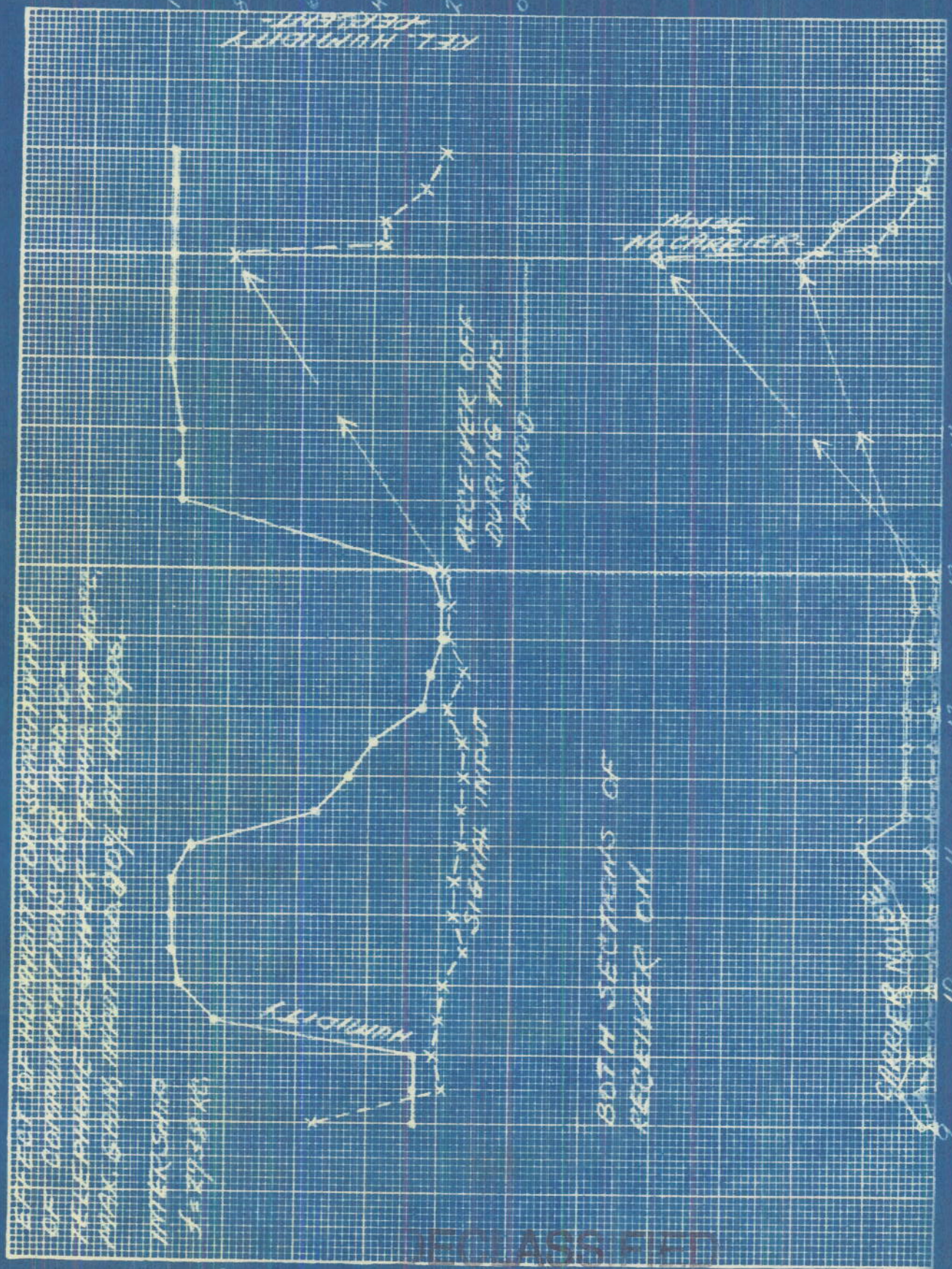
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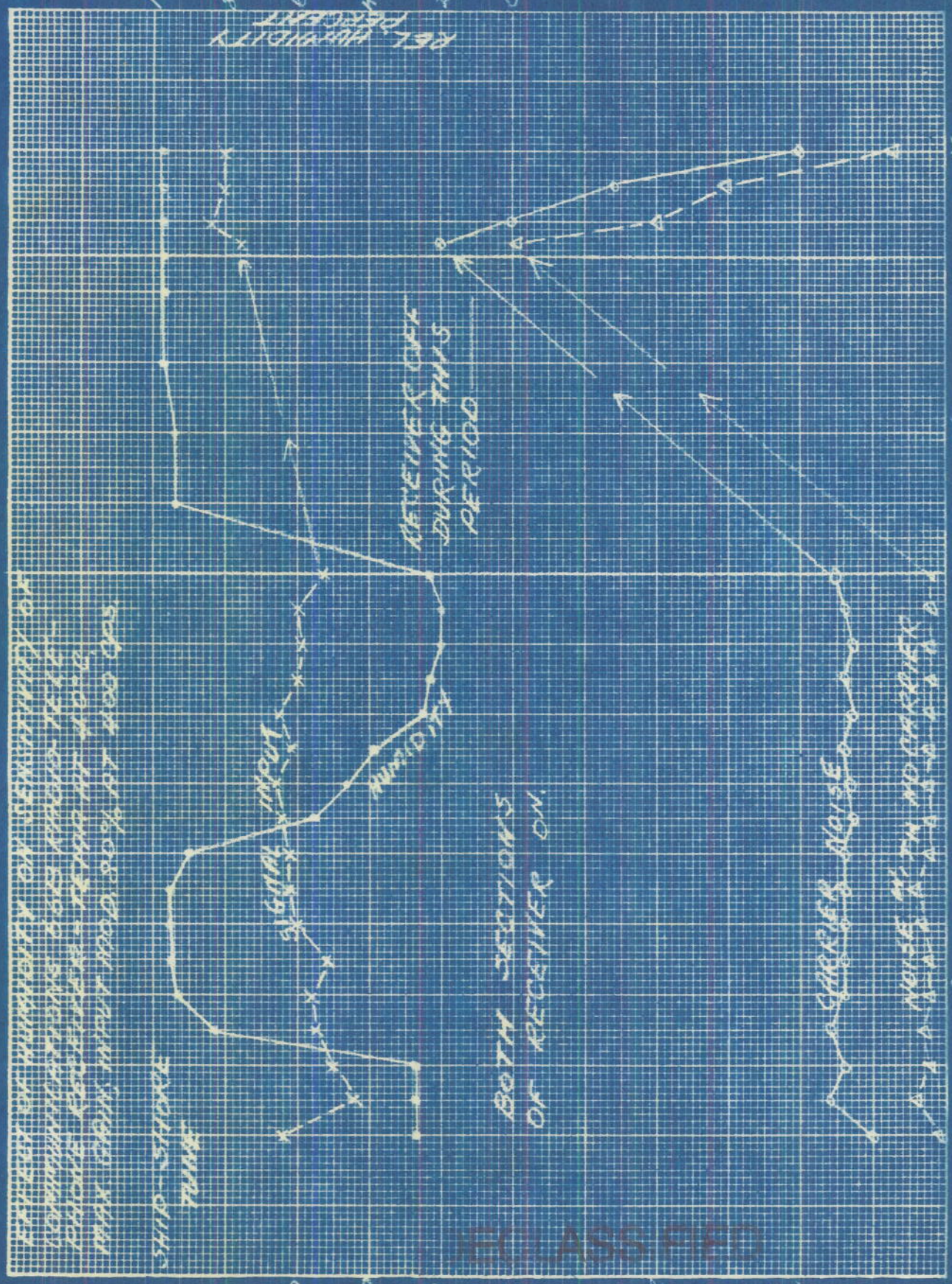
DATE 12-30-40



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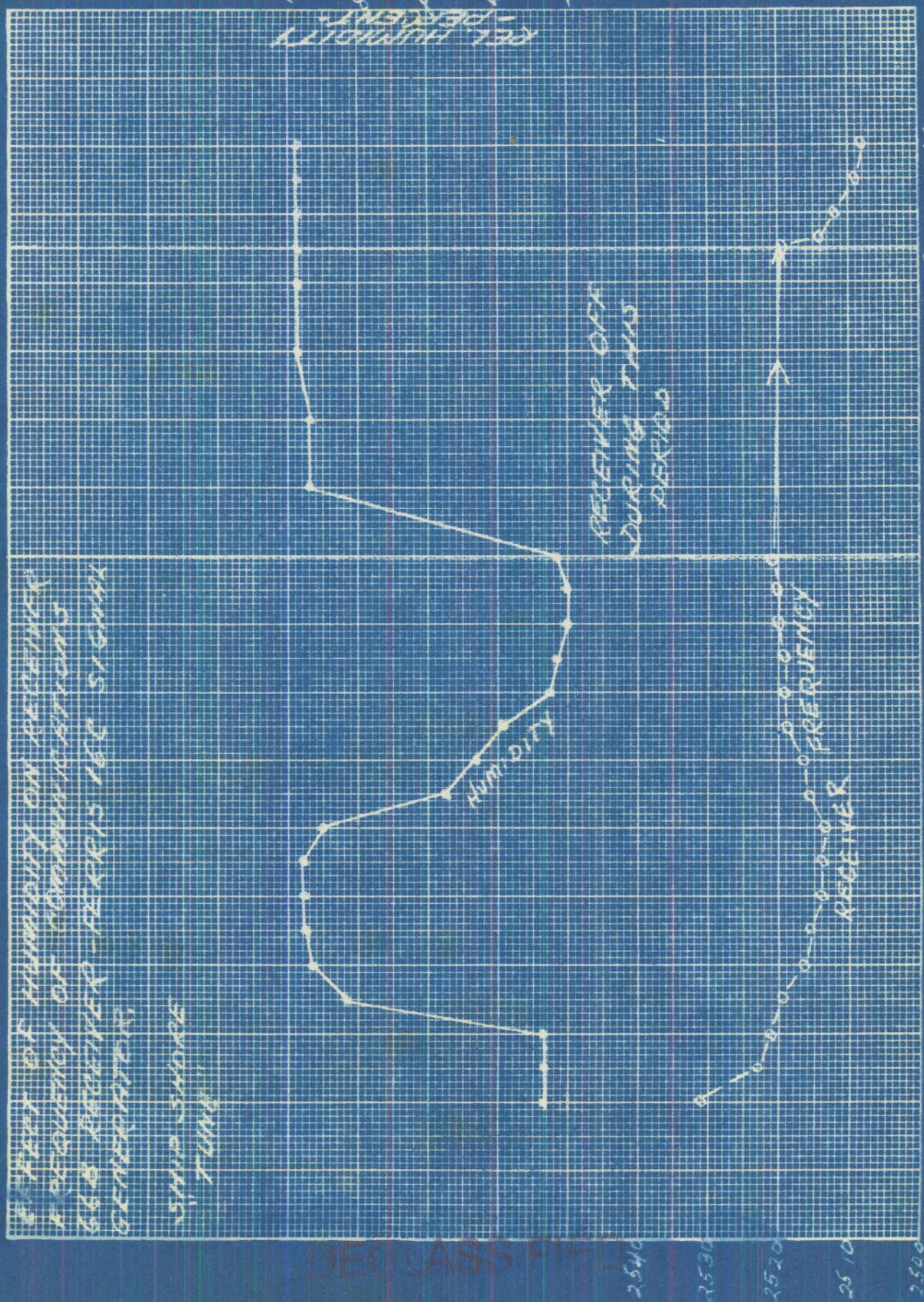
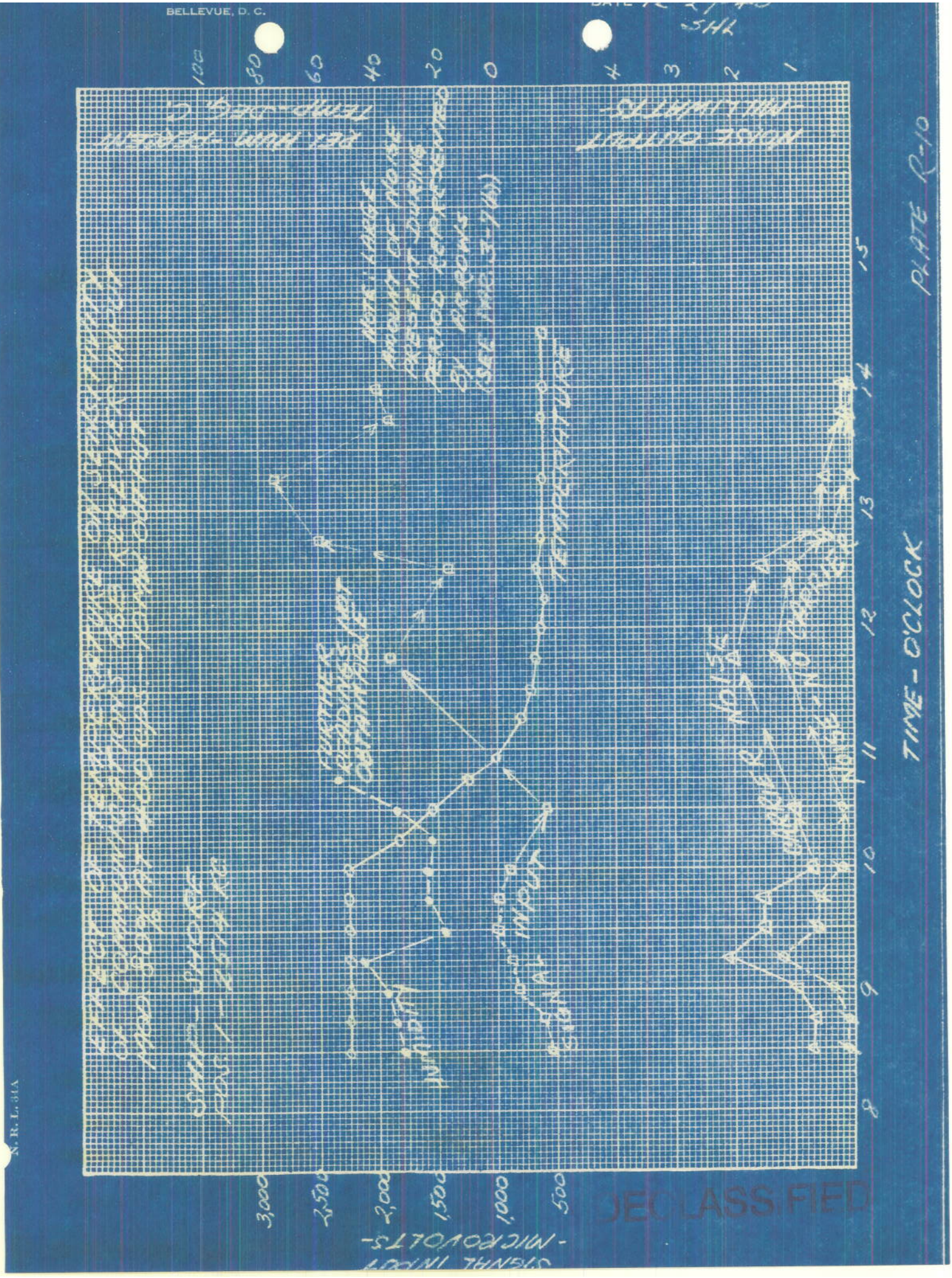


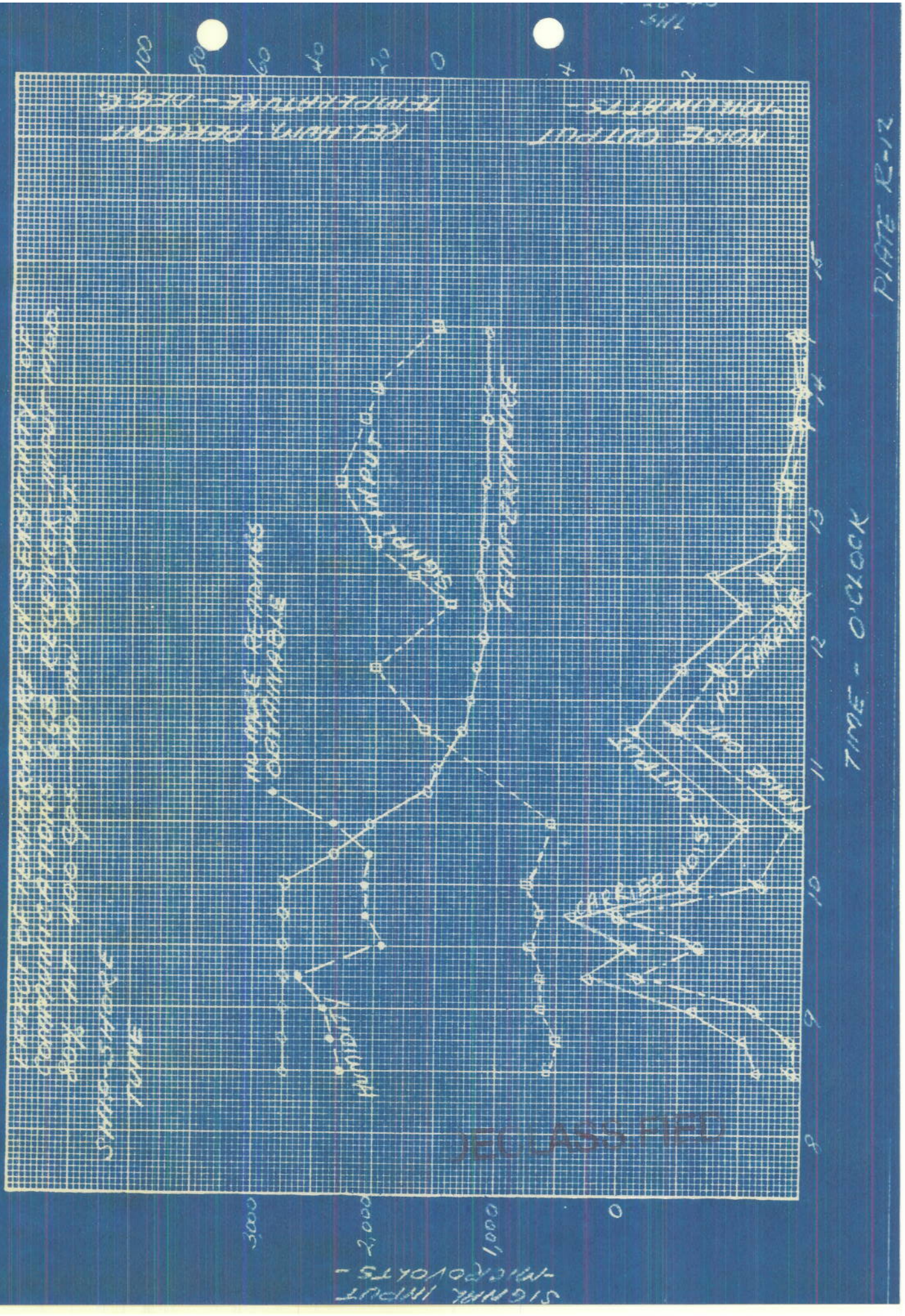
PLATE D-9

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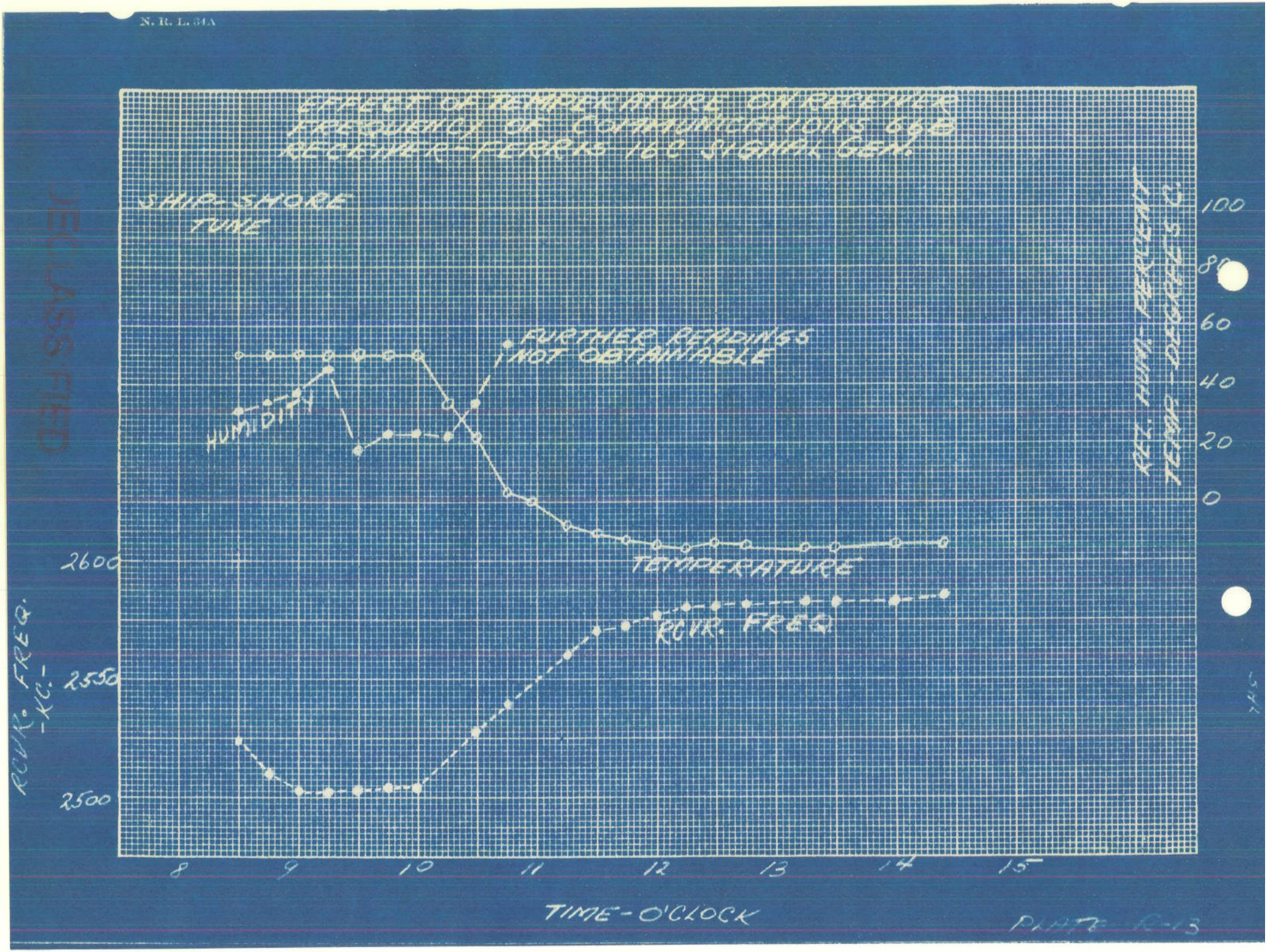
RDVR. FILED
-KC-


BELLEVUE, D. C.
PLATE R-10
TIME - O'CLOCK
SIGNAL INPUT - MICROVOLTS -
3,000
2,500
2,000
1,500
1,000
500
100
80
60
40
20
0
4
3
2
1
8
9
10
11
12
13
14
15
UNCLASSIFIED

TIME-O'CLOCK
PHASE A-11
UNCLASSIFIED


PLATE R-12
TIME - O'CLOCK
SIGNAL INPUT
-MICROVOLTS-
JECLASSIFIED

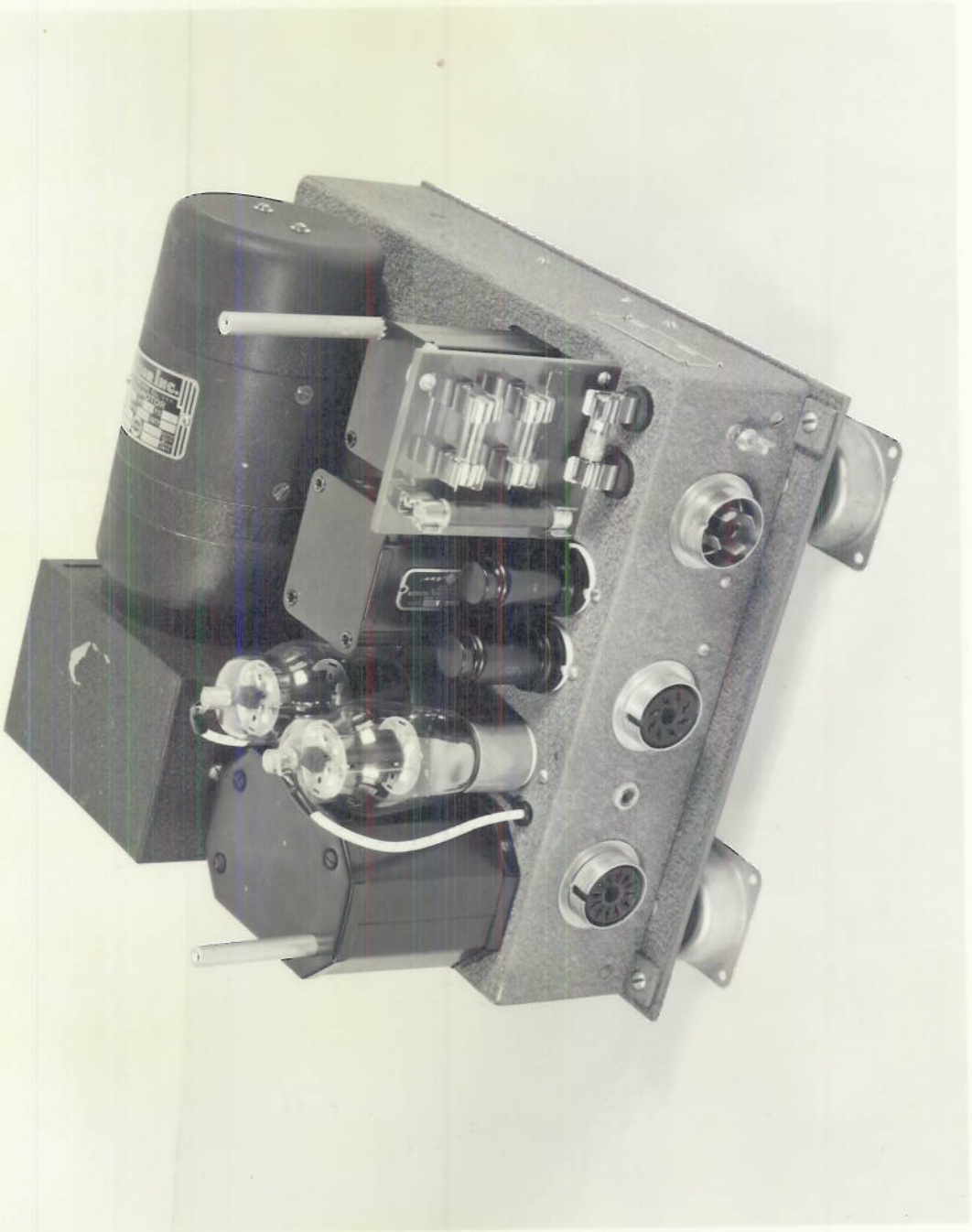
N. R. L. 31A


EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON FREQUENCY OF OSCILLATIONS OF RELAXATION PERIOD 10 C STARK CELL
SAME SMOKE TIME
HUMIDITY
FURTHER READINGS NOT OBTAINABLE
TEMPERATURE
ROTN. FREQ.
REL. HUM.-PERCENT
TEMP.-DEGREES C
100
80
60
40
20
0
2600
2550
2500
ROTN. FREQ. -KC.
8
9
10
11
12
13
14
15
TIME-O'CLOCK
PLATE 2-B



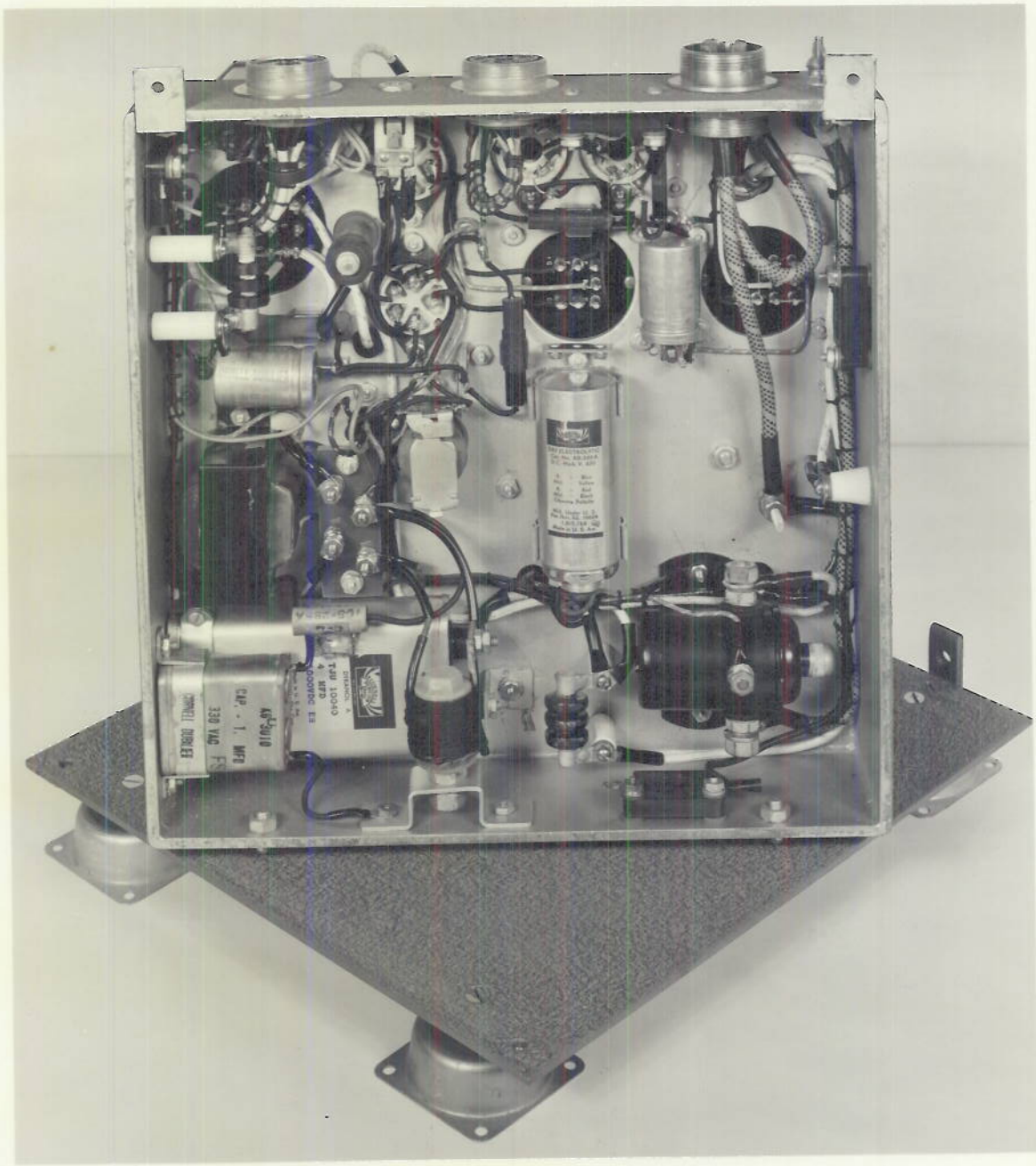
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PLATE TR I



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PLATE TR 2



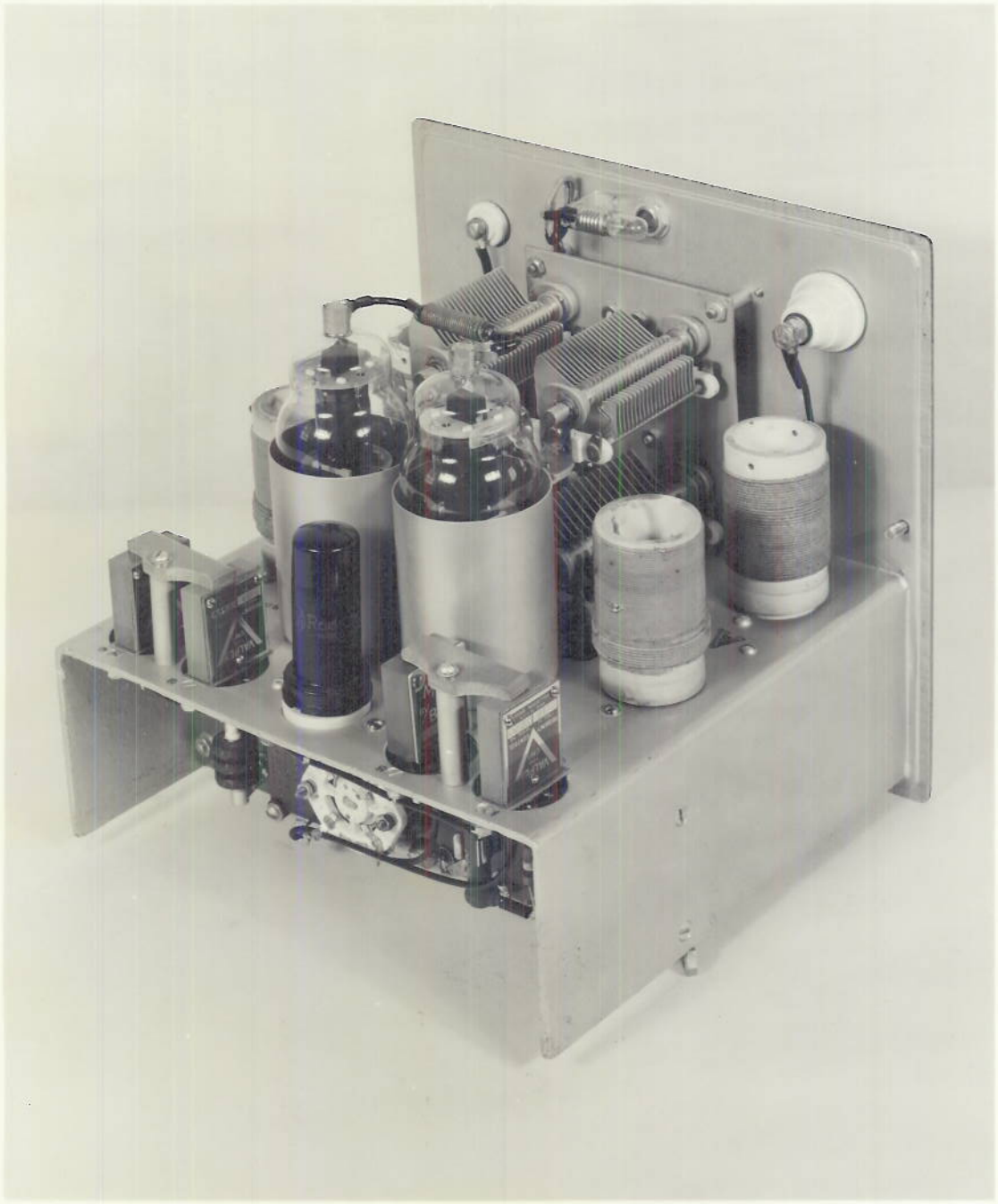
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PLATE TR 3



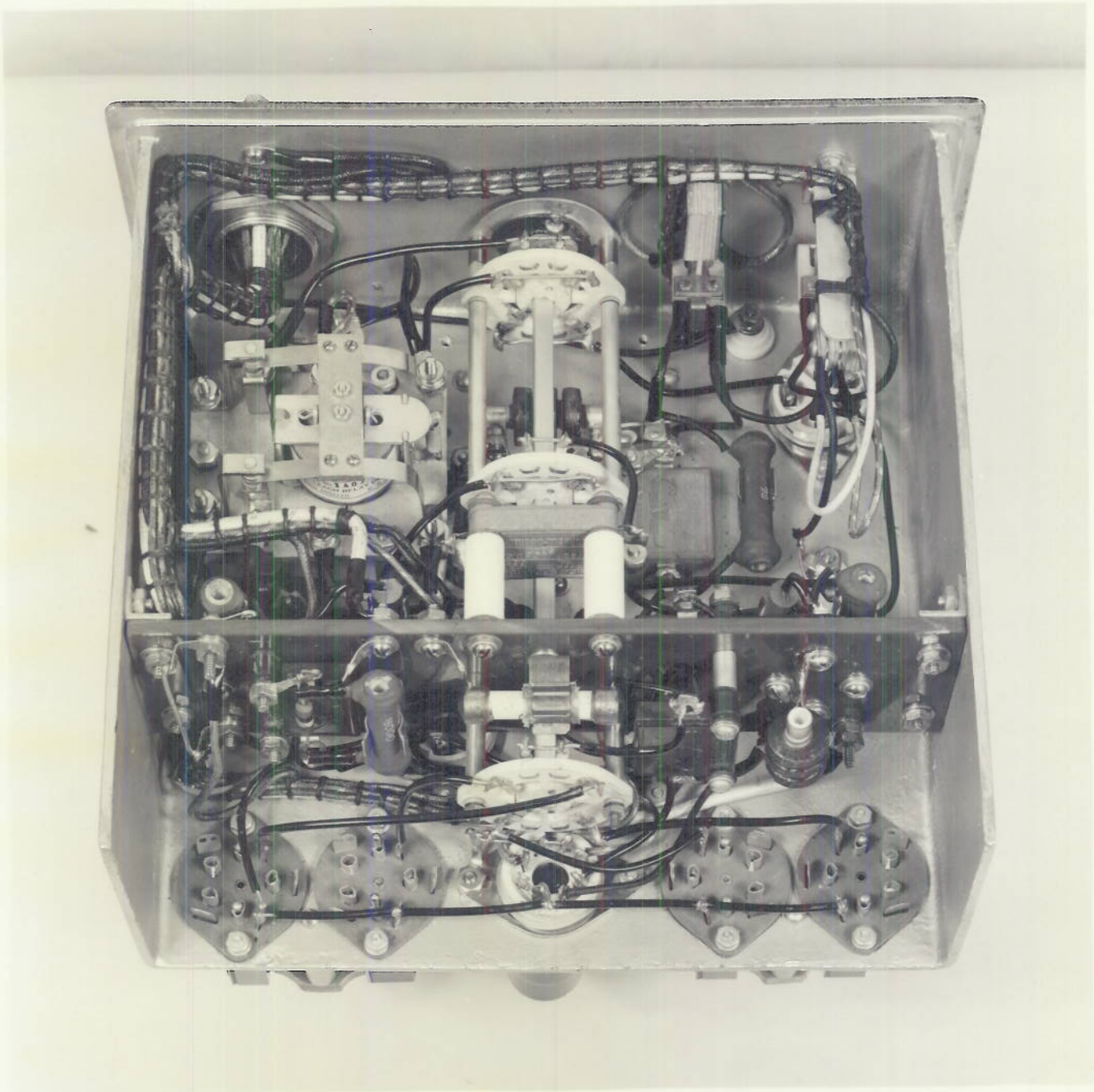
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PLATE TR 4



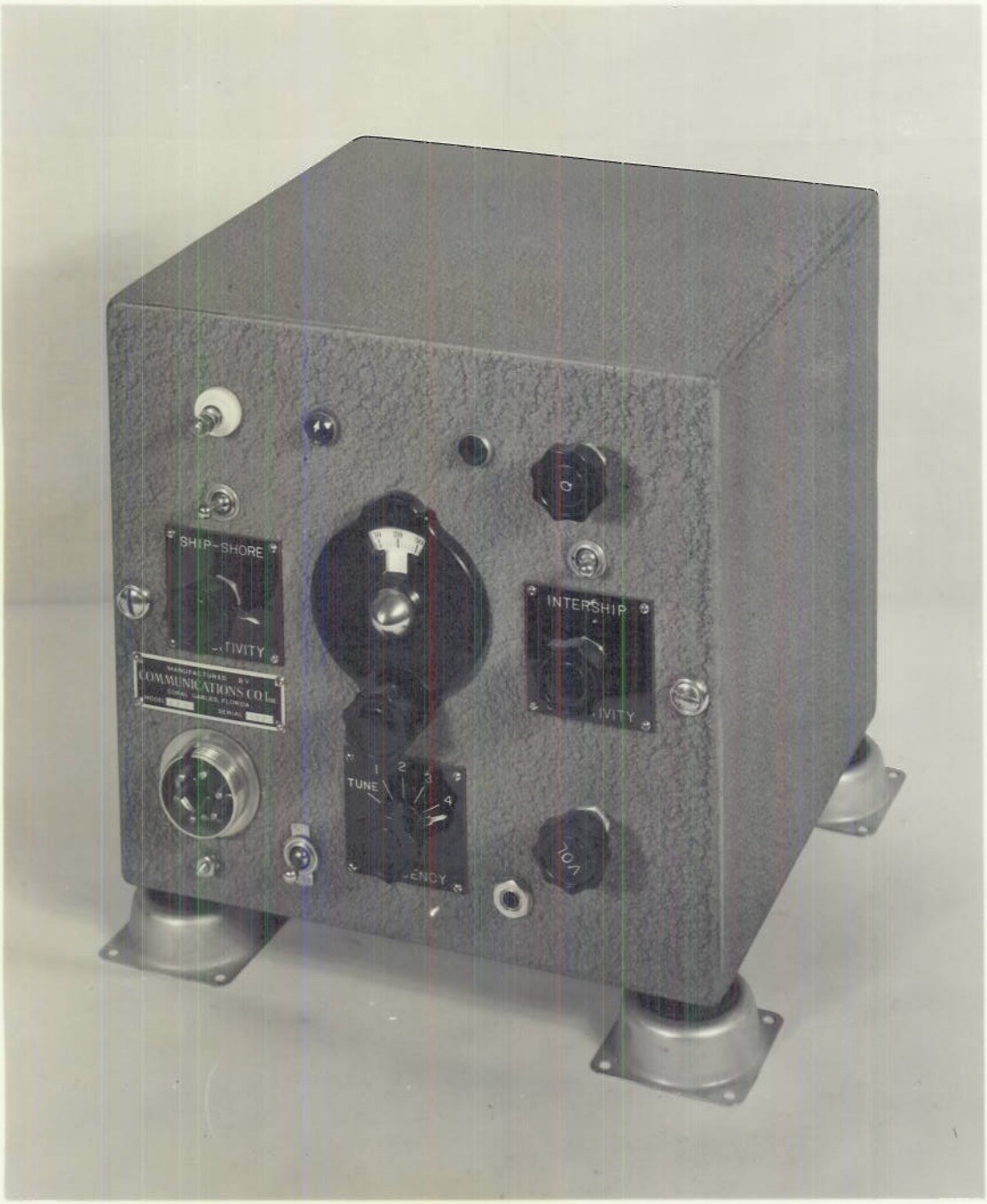
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PLATE TR 5



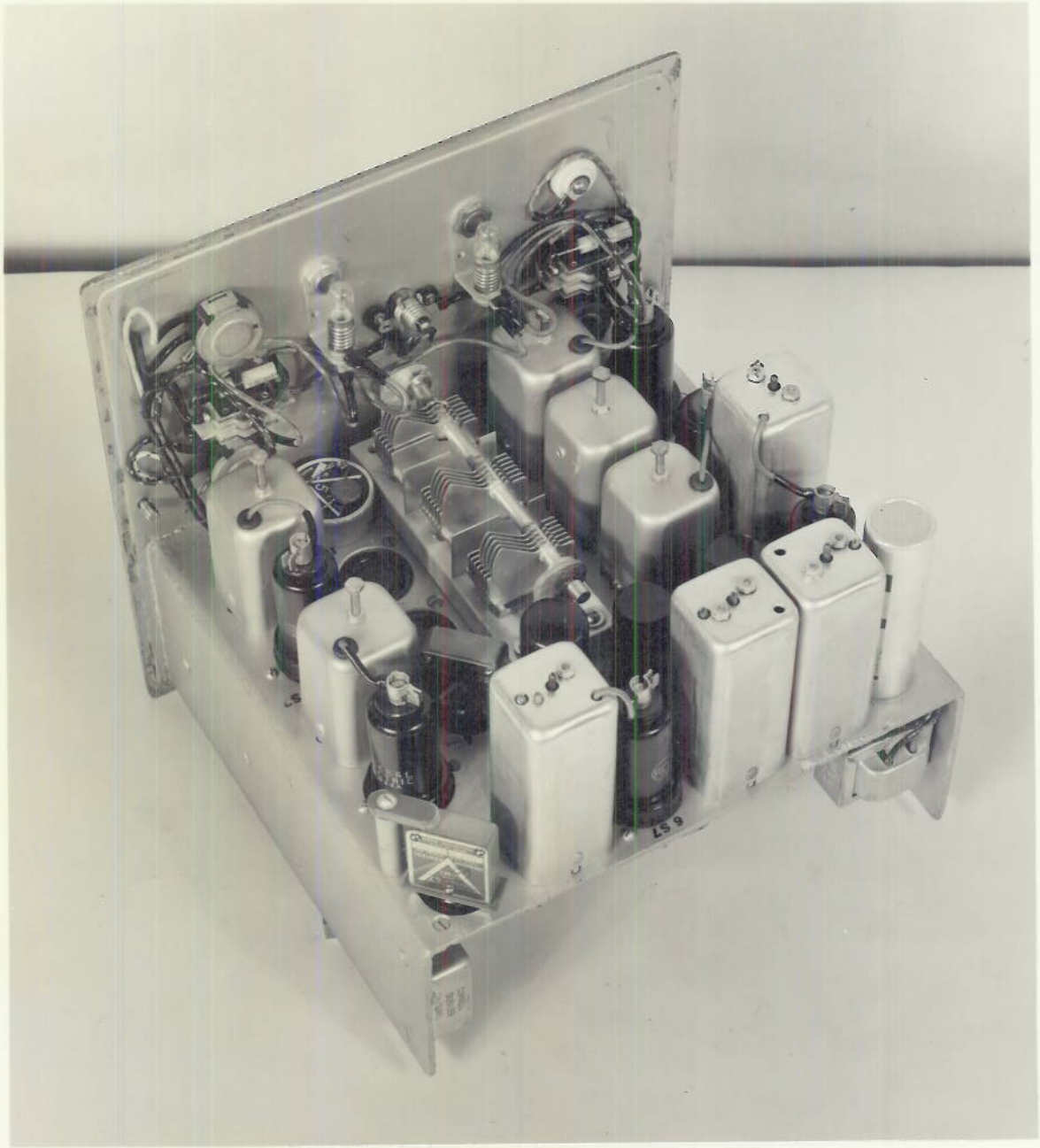
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PLATE TR 6



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PLATE TR 7



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PLATE TR 8



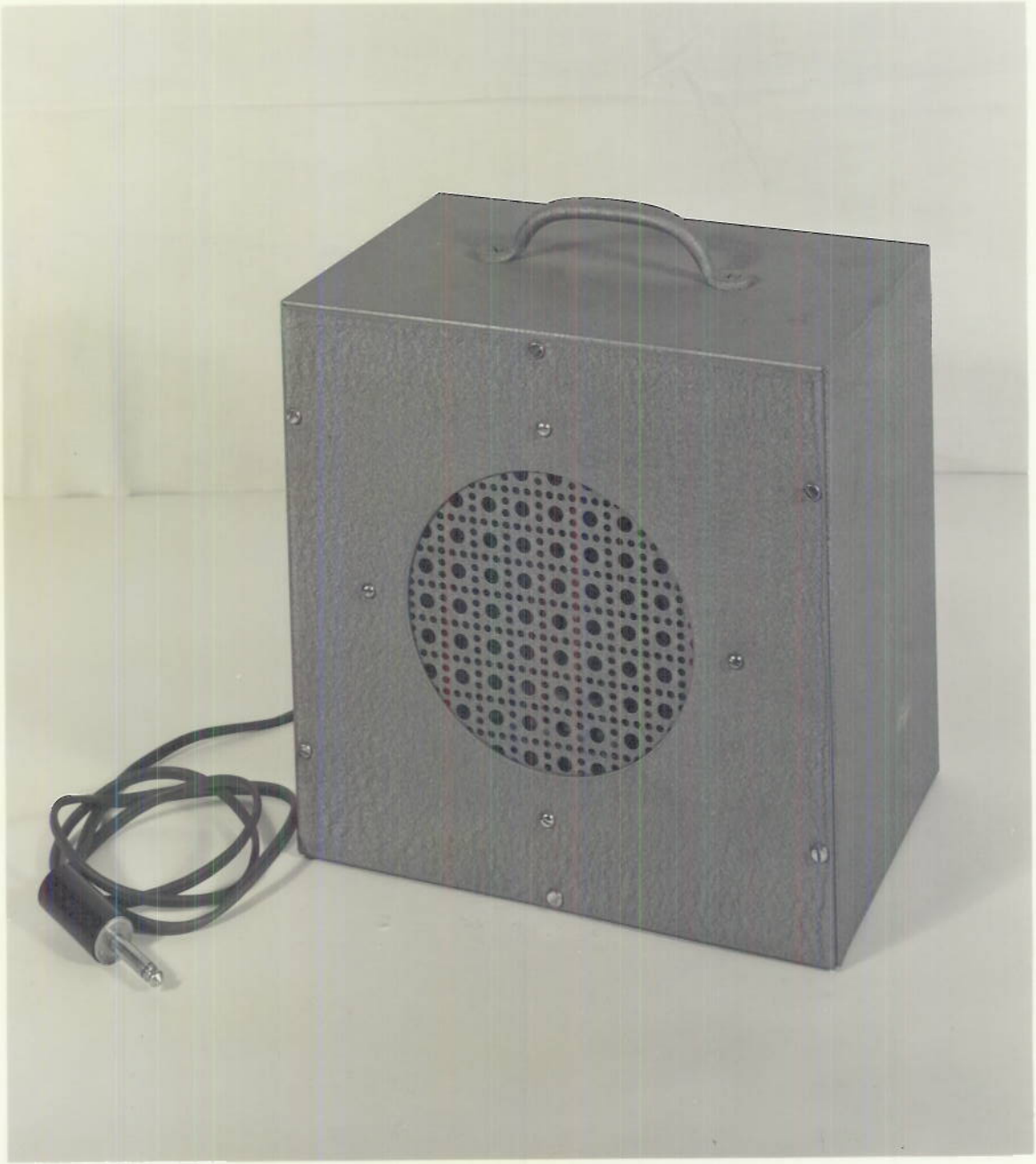
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PLATE TR 9



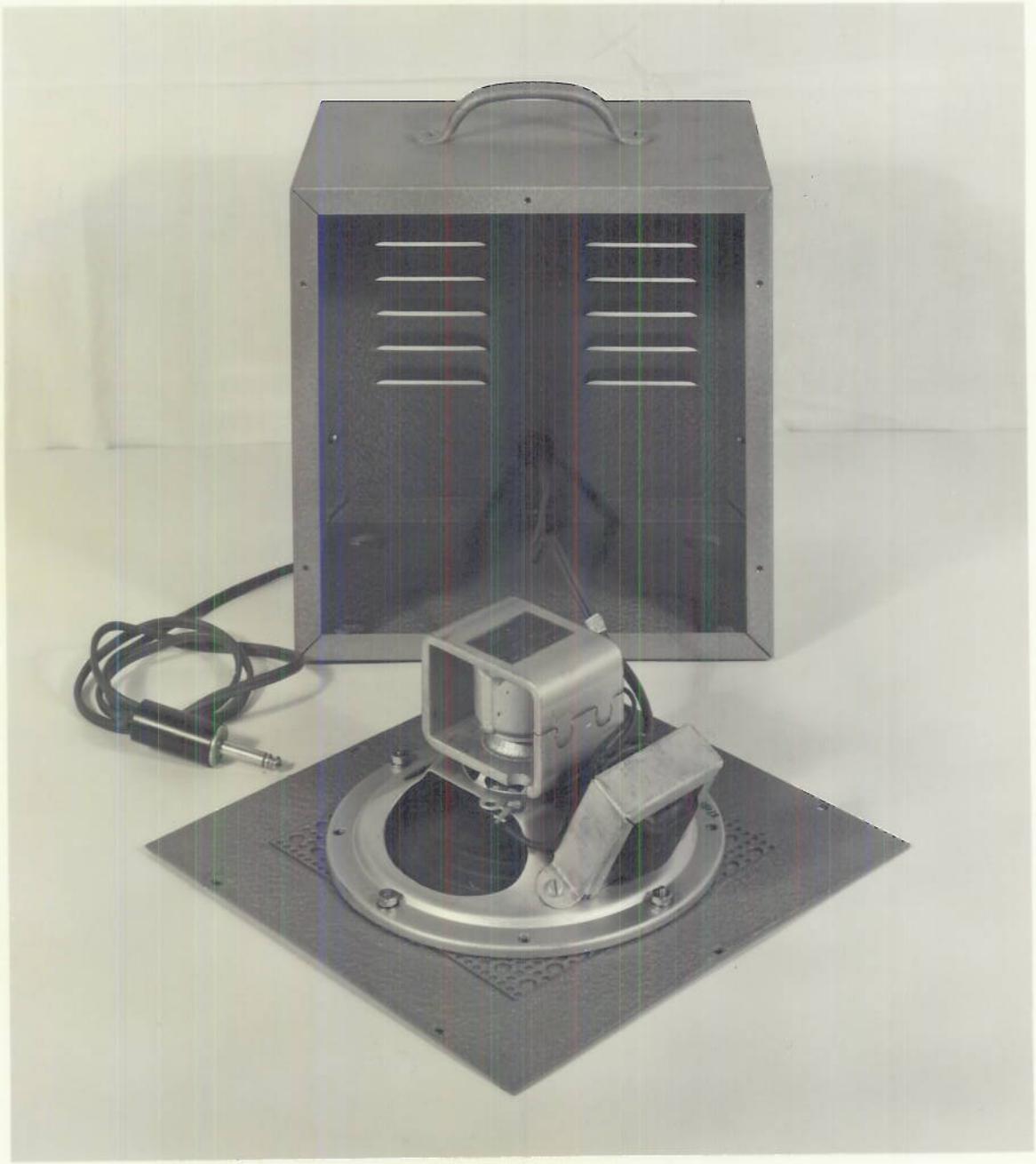
DECLASSIFIED

PLATE TR 10



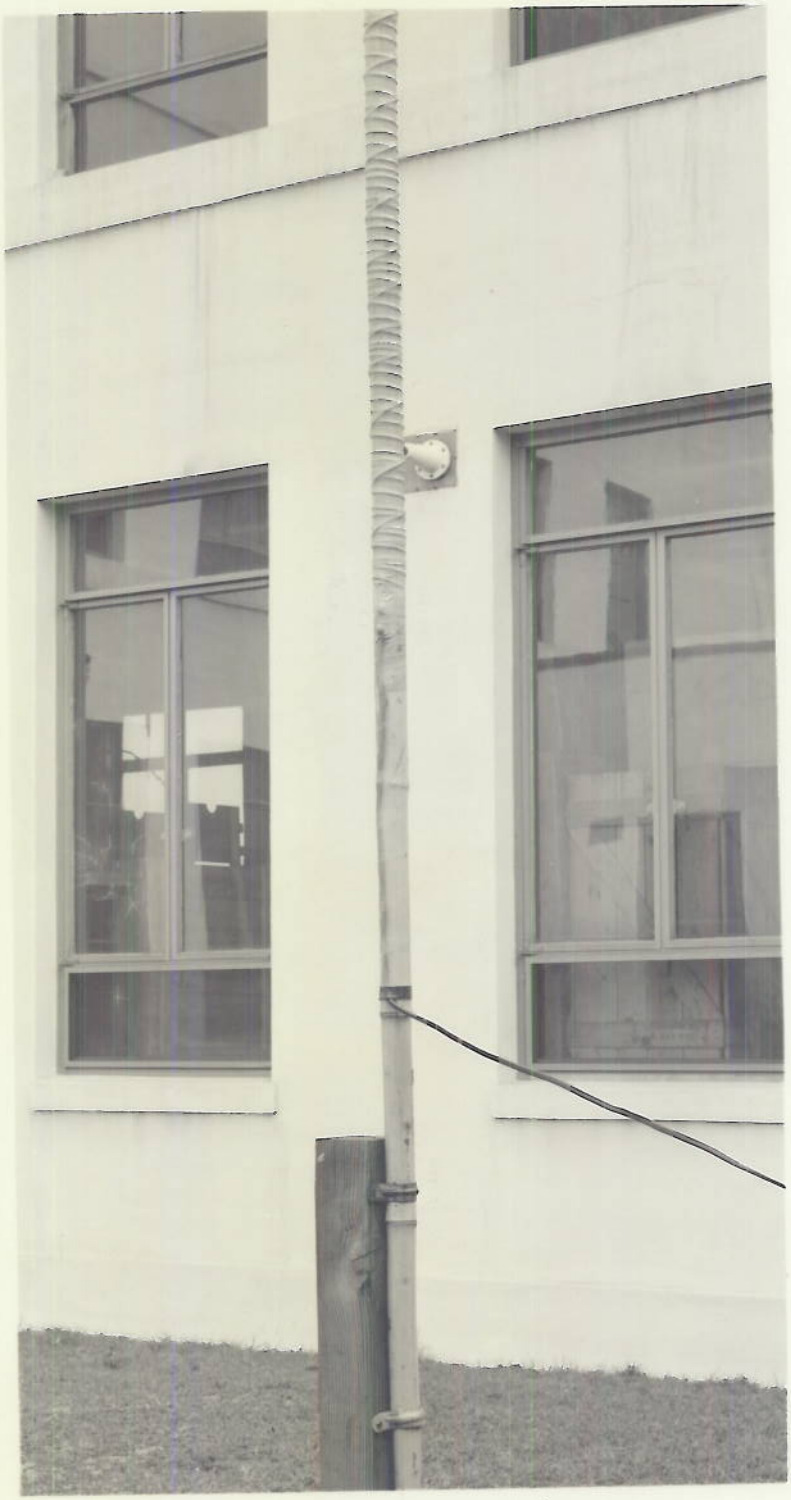
SECRET
DECLASSIFIED

PLATE TR II



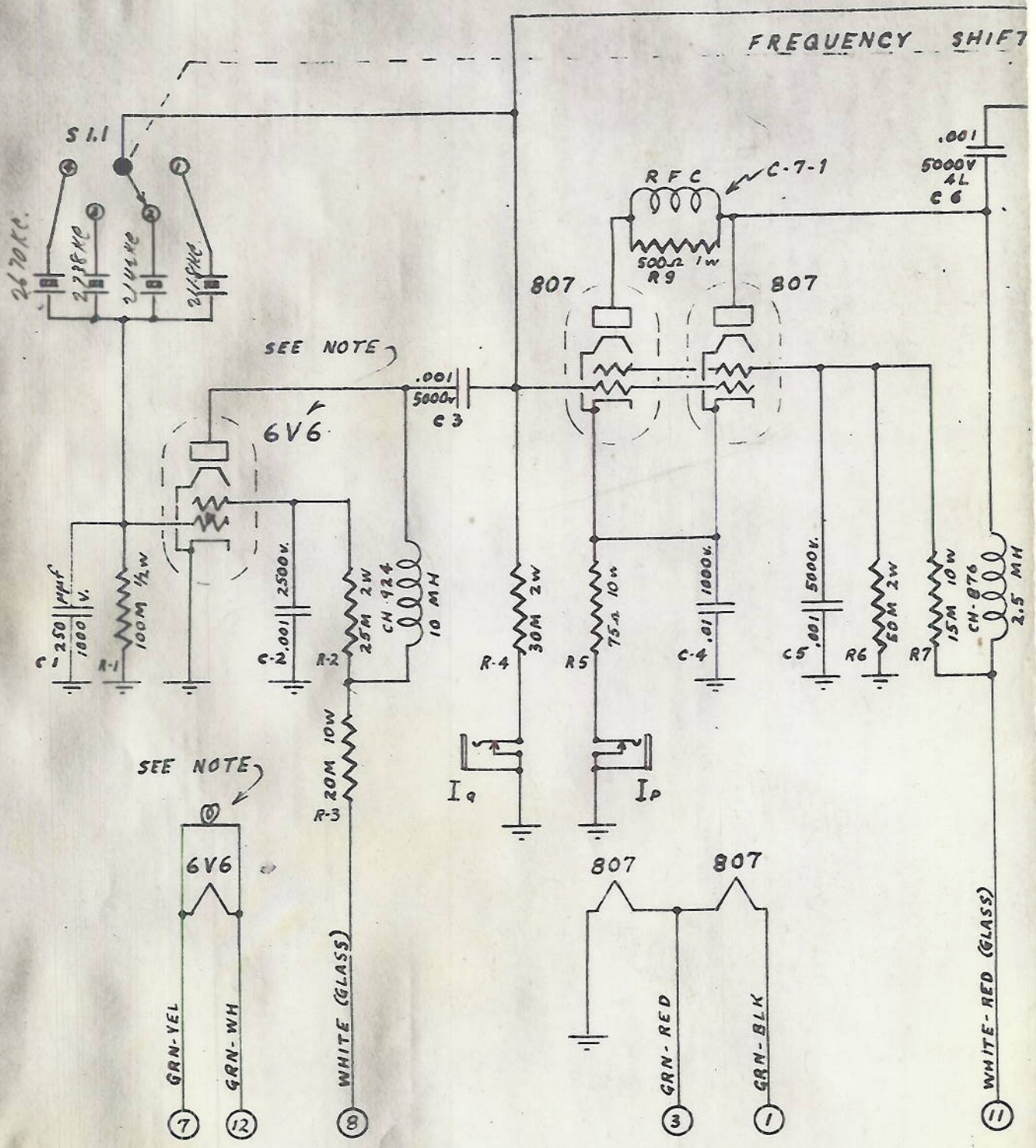
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PLATE TR 12

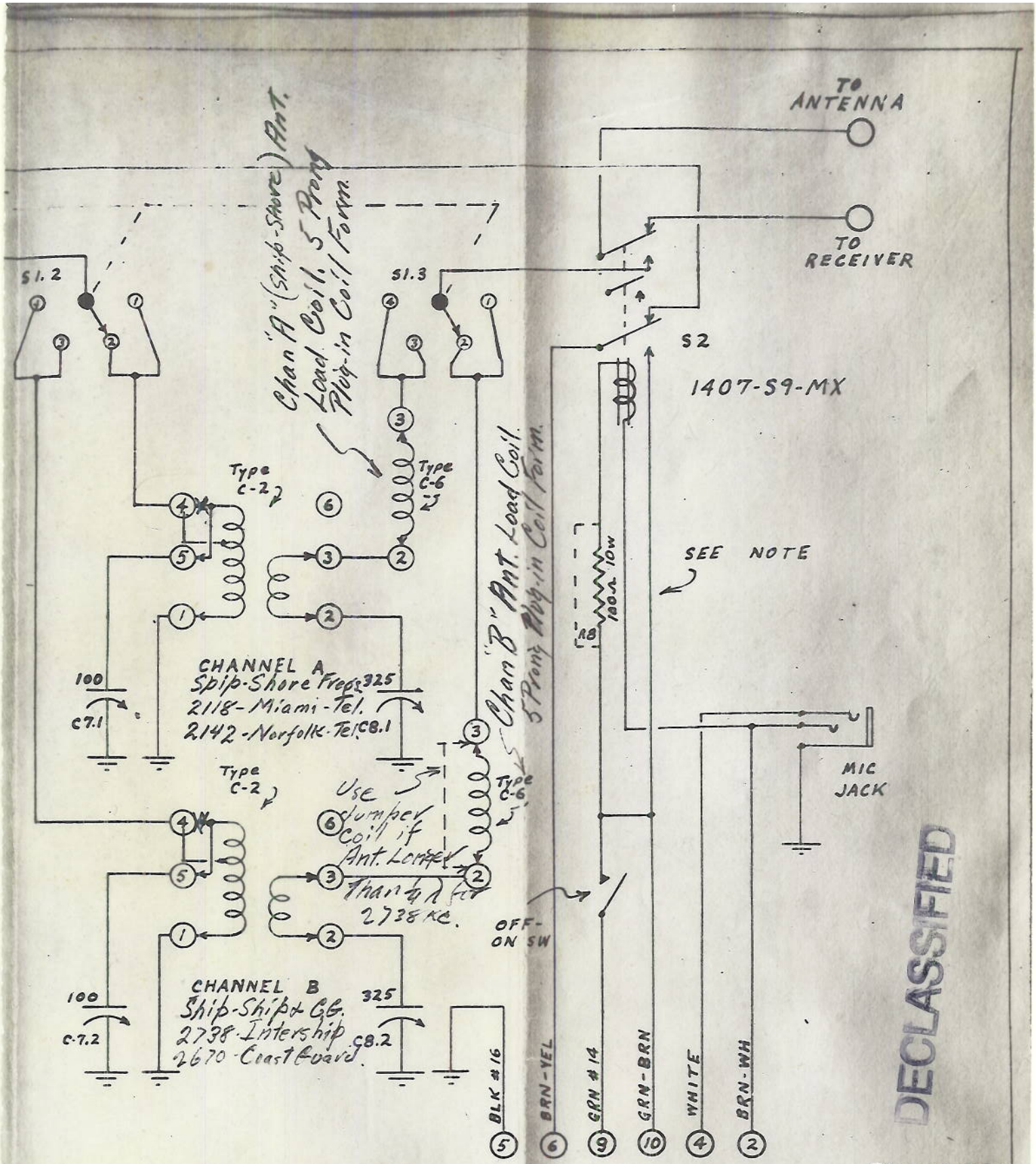


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PLATE TR 13



NOTE:
FOR 6 & 12 volt, use 6V6, 150 ma. pilot & short resistor, R-8.
FOR 32 volt, use 6F6, 250 ma. pilot & remove shorting jumper.
Pilots: 6.3 v. 150 ma. Type S-40.
6.3 v. 250 ma. Type S-46.



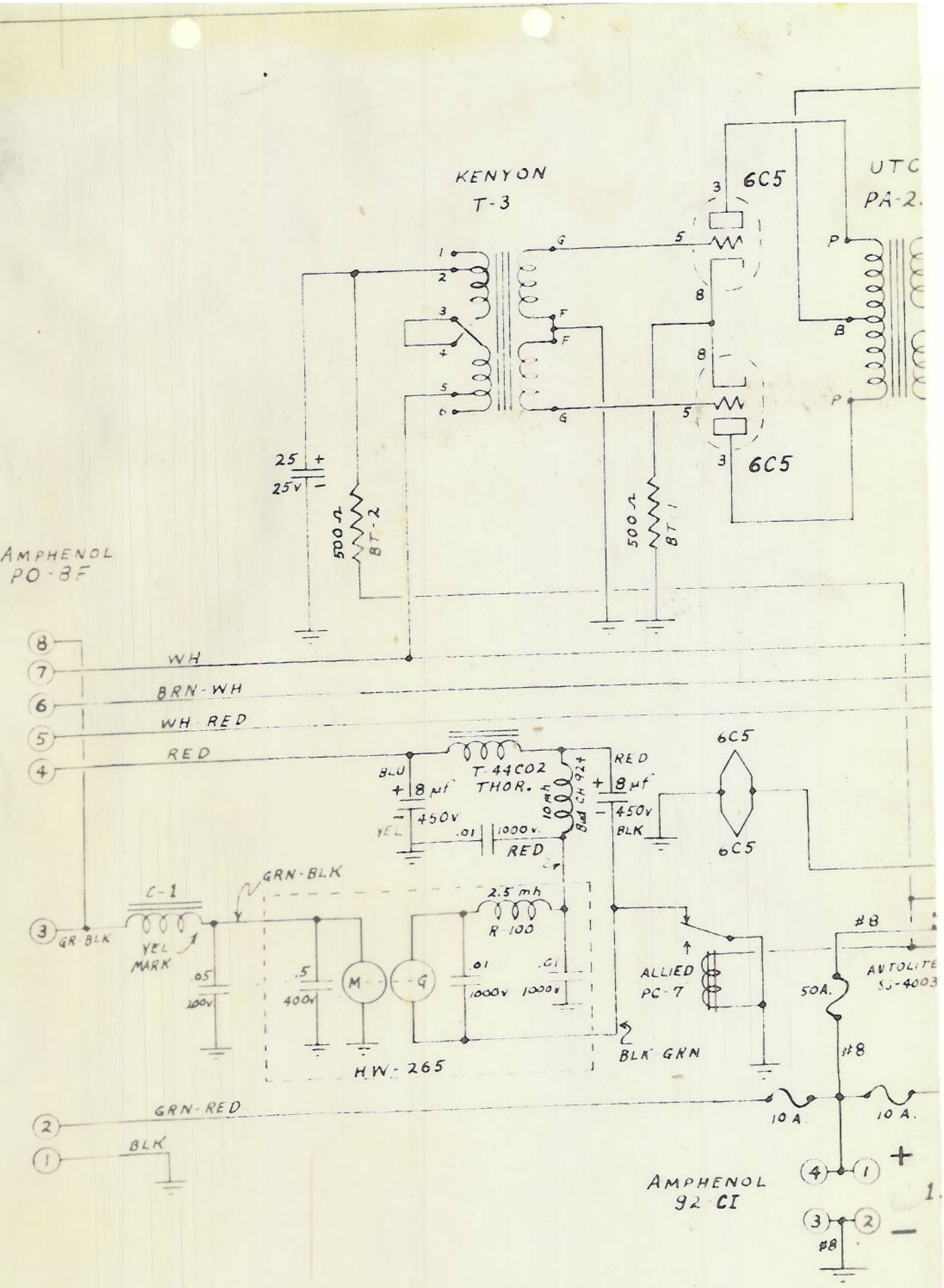
AMPHENOL PO-12MI
(CABLE END: 0-12FI)

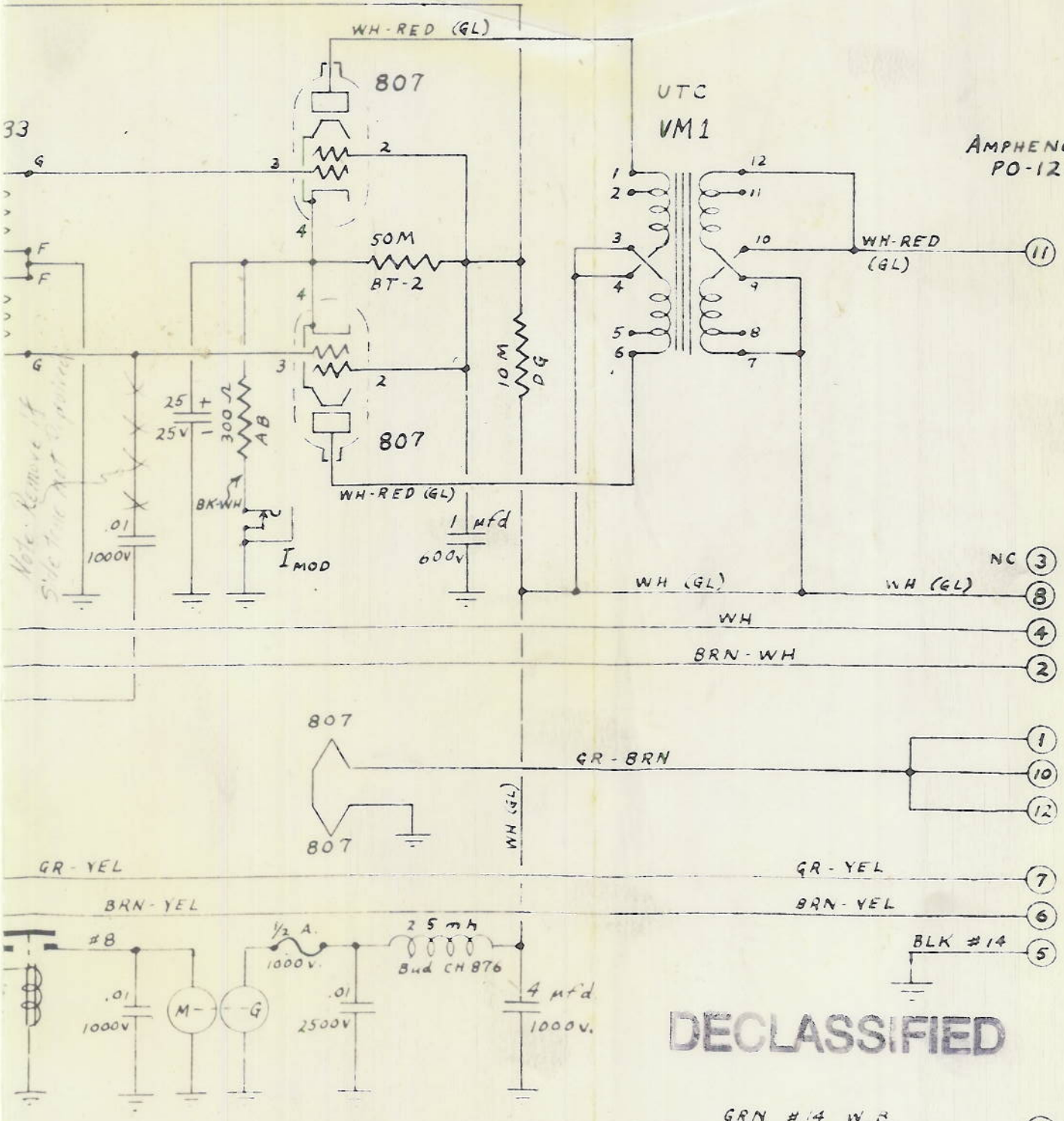
PLATE TR14

SCHEMATIC MODEL 50A	
DATE	5/31/40
DRAWN	H. L. W.
CHECKED	7/15/40
APPROVED	
COMMUNICATIONS CO. HIALEAH, FLA.	

50

1.1


KENYON
T-3
6C5
UTC
PA-2
25 +
25V -
500Ω BT-2
500Ω BT-1
6C5
AMPHENOL
PO-8F
WH
BRN-WH
WH RED
RED
T-44C02
THOR.
BLU
8 Mf
450V
YEL
.01
1000V.
RED
10mh
8Ld CH 924
RED
8 Mf
450V
BLK
6C5
GRN-BLK
C-1
GR-BLK
YEL MARK
.05
100V
.5
400V
M
G
2.5 mh
R-100
.01
1000V
.01
1000V
HW-265
ALLIED
PC-7
BLK GRN
#8
AUTOLITE
SS-4003
50A.
#8
10A
10A.
GRN-RED
BLK
AMPHENOL
92 CI
+
-
#8

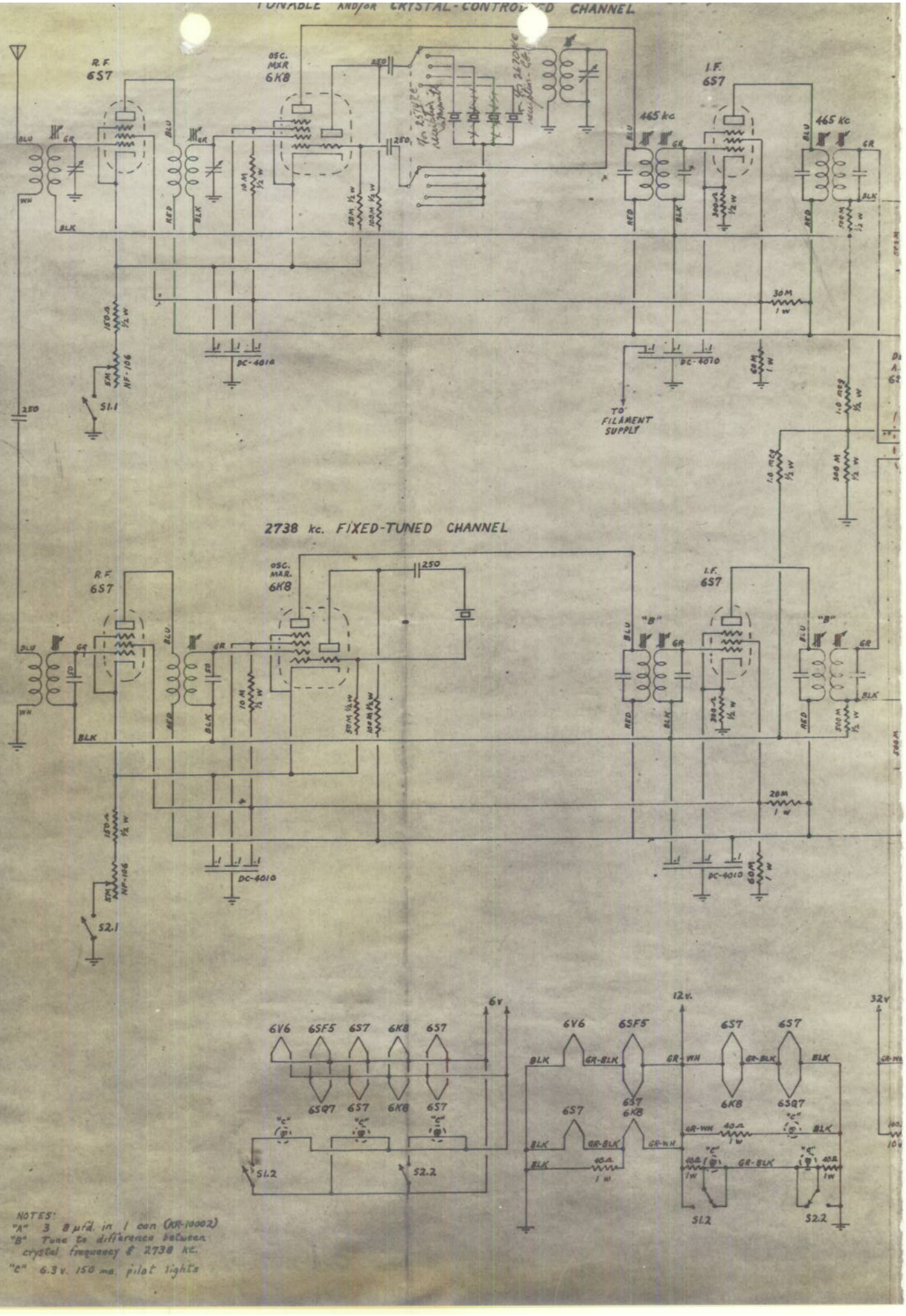


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PLATE TR15

SCHEMATIC MODEL 56B	56
DATE 5/29/40	
DRAWN H. L. W.	
CHECKED	1.2
APPROVED	
COMMUNICATIONS CO. HIALEAH, FLA.	

2 V.


TUNABLE AND/OR CRYSTAL-CONTROLLED CHANNEL
R.F. 6S7
OSC. MXR 6K8
I.F. 6S7
465 kc
465 kc
30M 1 w
DC-4010
DC-4010
TO FILAMENT SUPPLY
S1.1
2738 kc. FIXED-TUNED CHANNEL
R.F. 6S7
OSC. MXR. 6K8
I.F. 6S7
"B"
"B"
20M 1 w
DC-4010
DC-4010
S2.1
6V6 6SF5 6S7 6K8 6S7
6SQ7 6S7 6K8 6S7
S1.2
S2.2
6V6 6SF5 6S7 6S7
6S7 6K8 6K8 6SQ7
S1.2
S2.2
NOTES:
"A" 3 8 µfd. in 1 can (KR-10002)
"B" Tune to difference between crystal frequency & 2738 kc.
"C" 6.3 v. 150 ma. pilot lights

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exposed portions of the book, and the action produces a chemically inert layer of carbon which tends to prevent any further action of the acid. For this and other reasons sulphuric acid penetrates but slowly into the inside of a bound volume; even if methods could be devised for bringing the acid into intimate contact with all parts of the book, a prohibitive amount of acid will be required. Strong caustic solutions of sodium hydroxide were also tried. These changed the paper into a jelly-like mass which, however, could, on drying, be separated into sheets and the print still read. The use of caustic solutions in this manner can therefore be ruled out.

18. In general, therefore, as a result of theoretical and experimental work, it can be concluded that such chemical methods as these are not practicable.

(c) Water soluble inks.

19. The work of chemical criminologists indicates that it is quite futile to attempt to find water soluble inks and methods of using them that would not permit a competent chemist to render the matter legible. Here, again, this method would be limited in its application to the case of a sunken vessel so flooded that water would reach the contents of the documentary safes.

(d) Fugitive inks.

20. Chemical agents are known which will render illegible colored inks, but here again the work of criminological chemists indicates that in almost every case the bleached print can be redeveloped by the use of suitable chemical developing agents or by suitable physical methods.

(e) Incendiary devices.

21. It was suggested that a charge of Thermite be so arranged as to be set off automatically by the ingress of water in the case of sinking or manually in the event of capture, wrecking or stranding. Experiments on this method will be described below.

(f) Explosives.

22. Smokeless powder could be arranged to be ignited automatically or manually. A principal objection to this is one noted by representatives of the Office of the Chief of Naval Operations, namely, the danger to personnel involved in the presence of such a system. Further, it is probable that the result of setting off an explosive charge within a closed safe would be merely to open the safe and scatter its contents without completely destroying them. No experiments were made on this method.

(g) Gas torch devices.

23. It was suggested that a device similar to the acetylene water cutting torch with automatic control be provided to burn up the

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documentary material. The cylinders of compressed gas and the valve and igniting devices for this system would be prohibitively complicated and heavy and the operation of the device uncertain at best. Even if a suitable torch were devised, it would have to burn for several hours in order to destroy any quantity of bound volumes.

(h) Electric furnace.

24. In this, the interior of the safe containing secret documents would be fitted with high temperature electric heaters connected to the emergency sources of electric power. In emergency, these heaters would be manually or automatically turned on to destroy the documents by heat. The difficulties with this device are first, its dependence upon electric power under all circumstances, and second, that the documents might not be sufficiently destroyed to become illegible. Experiments on this method are described below.

DESCRIPTION OF EXPERIMENTS

25. As a striking illustration of the difficulty of destroying a book, the following experiment was made. A typical cloth-bound book measuring about 6"x9" with about 1,000 thin paper pages was thrown into the Laboratory's electric steel furnace containing a bath of molten steel at a temperature of 3,000°F. At the end of 5 minutes, the remainder of the book was removed from the furnace. Several hundred pages in the middle of the book were recovered and of these about half of the area of each page was practically unchanged and perfectly legible.

26. Next, a large obsolete safe was wired with electric heating element resistance wires capable of dissipating about 5 kilowatts. Inside it was then stacked about 15 pounds of books simulating the normal contents of such a safe (an actual safe would, of course, contain much more than 15 pounds). The current was turned on and continued for several hours, at the end of which time the safe was allowed to cool and opened. The books in the middle of the pile were practically unchanged. The outer ones were completely charred, the pages remaining being merely thin sheets of carbon. While these charred books were extremely brittle and fragile, nevertheless, by the exercise of great care, the pages could be separated almost intact and the printing readily made out for the reason that the charred ink was of a different color from the charred paper. The results of this experiment confirm the experience of (1) fire insurance authorities in recovering the contents of safes in office buildings following severe fires, (2) the United States Treasury Department in reclaiming burned money, and (3) the Bureau of Investigation of the United States Department of Justice in reading burned paper documents.

27. The Thermite method was studied in two experiments. In the first, about ten pounds of books were stacked in the normal manner in a refractory brick enclosure. A twenty-pound charge of Thermite contained in a refractory vessel was so arranged that the molten mass poured onto the books. When the Thermite reaction was complete, the

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whole mass was covered with an insulating layer of sand and permitted to cool down. When the solidified iron was removed, it was found that the outer portions of the pile of books were charred beyond recognition, but in the center of the pile the pages were unchanged and easily legible. Next, a similar pile of books was arranged with a charge of Thermite resting on them. The charge of Thermite was set off and, when the reaction was complete, the whole mass was covered with sand and permitted to cool. Here, again, when the books were examined, it was found that the external portions had been destroyed but that a large portion of the interior of the book pile was unchanged. These experiments confirmed the theoretical prediction that the low thermal conductivity of paper and the large quantity of energy requisite to decompose it would defeat any attempts at destruction by Thermite of more than a limited quantity of paper material.

28. It is considered that the suggestion for using Thermite may rest on a misconception of its function in incendiary bombs. In those, the Thermite, because of its high temperature, ignites any inflammable material with which it comes in contact and the combustion of that material continues in the surrounding air. In inflammable material contained in a relatively airtight enclosure such as a safe, these conditions would not obtain, and the amount of destruction of those materials would be limited by the energy content of the Thermite itself.

29. No experiments were carried out on methods of destroying the Electric Cipher Machines aboard ship.

30. Since the possibility of success in finding a suitable system for destroying the present types of confidential and secret matter in the quantities now contained in safes aboard ship appears from the above discussion and experiments to be rather remote, this Laboratory has considered some radically different methods for publishing the Naval confidential and secret documents. One of these methods will now be considered.

31. In a conference with the Office of the Chief of Naval Operations concerning this subject problem, this Laboratory suggested that the Office consider the feasibility of printing some of its confidential documents on motion picture film for use aboard ship, the destruction of such film being very easy and positive in the event of the sinking, stranding, etc., of the vessel. At the time of the conference, it was known that the Eastman Kodak Company had developed equipment - called the Recordak System - for printing documents on film and devices for reading this film. The Recordak System is in extensive use in banking and business establishments for the recording and filing of documentary material, but it was appreciated that the Eastman equipment was not well adapted to Naval use.

32. This Laboratory has recently learned that Lieutenant Rupert H. Draeger (MC) USN has developed a system for the photographic reproduction of documents under the auspices of Science Service and with the collaboration of several of the government departments, including the library of the Naval Medical School. The development has reached the

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stage where his system is in wide use. It is considered that it is well adapted to a number of Naval uses, among which is the one studied in this report.

33. In the Draeger System, a specially developed camera, shown in Plate 1, is used to photograph documents, pages of books, letters, drawings, etc., on to standard motion picture film. This film is then developed and either used in that form or else positives in any quantity are prepared from it. By the use of special reading equipment, shown in Plate 2, which comprises means for projecting the image of this film onto a small ground glass screen, the reproduction can very easily be read. The reading machine, as at present developed, is slightly larger than a typewriter. A 1500 page book can be reproduced on a reel of motion picture film less than 3 inches in diameter (35 mm wide) at a cost of one-tenth of a cent per page for the original film.

34. In the opinion of this Laboratory, the use of the Draeger System motion picture film to carry confidential data aboard ship would have the following advantages:

(a) Secrecy. It is recognized that to minimize the possibility of compromise of code books, etc., all stages in the production of such books must be under control of the Chief of Naval Operations. When the typesetting, printing, and binding are done by an outside agency, as at present in the case of certain of these documents, the danger of compromise is increased. With the Draeger System, a master book could be typewritten or printed in the Office of the Chief of Naval Operations, then photographed, printed and distributed by Naval personnel under close supervision.

(b) Ease of Distribution. In the event that the known compromise of a code made necessary the replacement of the code books in service, the distribution of these to the ships of the Fleet would be a difficult matter. With the code book printed on film, the requisite number of copies could be carried in a suitcase and airplane transportation could be used to expedite the procedure as, for example, in reaching the Hawaiian Islands.

(c) Rapidity of Production. If the known compromise of a code system made necessary the immediate adoption of new code books, their production under the Draeger System could be very rapid.

(d) Ease of Use. Once the personnel became trained in the use of this system, it is believed that it would be almost equal in rapidity to the standard books. With the collaboration of Dr. Draeger, the rapidity of using the system was tested by comparing the time required to obtain data from a film with the time required to use the book from which the film was made. The film system was only slightly slower, even with an inexperienced operator. In certain cases, the Draeger System

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would be much easier to use. For example, a lightweight reading device could be developed by the use of which a tactical officer on the bridge could have a set of the significant tactical signals immediately available throughout an action. Similarly, suitable reading machines could be disposed in convenient parts of the ship.

(e) Ease of Destruction. The destruction of film confidential documents would be very easy and positive. Nitrate film could be used, in which case they could be ignited by a match or cigarette lighter, while safety film could be destroyed almost as easily. In the event of sinking of the vessel, the action of sea water would soon destroy the legibility of the film. If the film were thrown overboard, the chance of its being found by a diver would be most remote, owing to its small quantity. On the other hand, if standard movie film should prove to be too perishable, as from frequent handling, a satisfactory film could without doubt be developed.

(f) Weight and Space Saving. The use of motion picture film to carry confidential data would save a great deal of space and, by greatly reducing the size of the safe necessary, would save considerable weight.

(g) Economy. By the use of the Draeger System, a complete set of code books could be produced and distributed at a fraction of the cost of the present ones. This would be economical and would as well permit more frequent change of the codes without much added expense. However, the initial investment in equipment to make this system effective would be rather high. But it is considered that the importance of the subject problem might justify this initial expense.

CONCLUSIONS AND RECOMMENDATIONS

(a) Facts Established

35. It is considered that the above discussion, theoretical considerations and experiments have shown that:

(1) There is no positive practicable method for the destruction of the quantities of secret and confidential material now contained in the safes of Naval vessels in the event of their being stranded, sunk, wrecked or captured.

(2) The chemical and physical nature of paper is such as to make difficult its destruction, especially in large masses.

(3) The prevention of the compromise of secret and confidential documents aboard ship would be simplified if the quantity of such documents could be reduced to a minimum.

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(4) Small quantities of paper documentary material, preferably stored as sheets rather than bound in books, could be destroyed:

(a) By Thermite in sufficient quantity.

(b) By burning the paper and carefully disintegrating the resulting sheets.

(c) By violent agitation in a caustic solution so that the paper is entirely disintegrated into its component fibers.

(b) Opinions

36. It is considered that the importance of positively preventing the compromise of secret and confidential material aboard ship in the event of its being stranded, sunk, wrecked or captured is so great as to justify the Office of the Chief of Naval Operations making a comprehensive study of means for reducing the quantity of such material to a minimum, for only by minimizing the quantity can its destruction to prevent compromise be insured.

37. In a conference on this problem in the Office of the Chief of Naval Operations, one of the representatives of that Office pointed out what seemed to him the futility of destroying books descriptive of some of the Naval materiel about the ship under conditions where it would be impossible to prevent the materiel itself from falling into enemy hands. He pointed out, for example, how difficult it would be to prevent the torpedoes from falling into enemy hands in case the vessel were sunk or stranded in shallow water and that it would appear to be immaterial whether the books describing those torpedoes also were disclosed. He considered that this applied equally to other books under the cognizance of all the materiel bureaus.

(c) Recommendations

38. It is recommended:

(a) That the Office of the Chief of Naval Operations ascertain the feasibility of using the motion picture film method developed by Lieutenant Draeger (MC) USN for the dissemination of certain secret and confidential Naval data for use aboard ship. If the Office considers this method feasible and that the expense of putting it into use justified, this Laboratory could investigate the practical details of using it.

(b) That the attempt be made to reduce to a minimum the quantity of secret and confidential material, the compromise of which would be most serious.

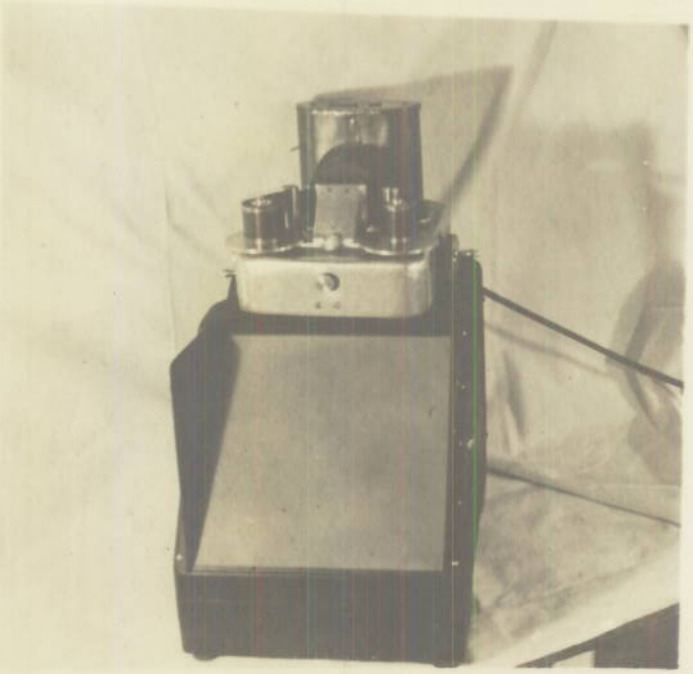
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Camera for photographing documents onto motion picture film, Draeger system.

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Plate 1



Reading machine for Draeger system motion picture film demonstration.

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